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COMPRESSED AIR

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INDEX TO ADVERTISERS.

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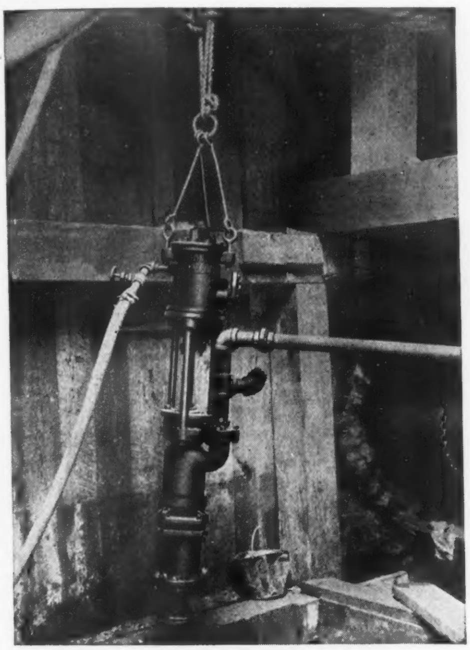

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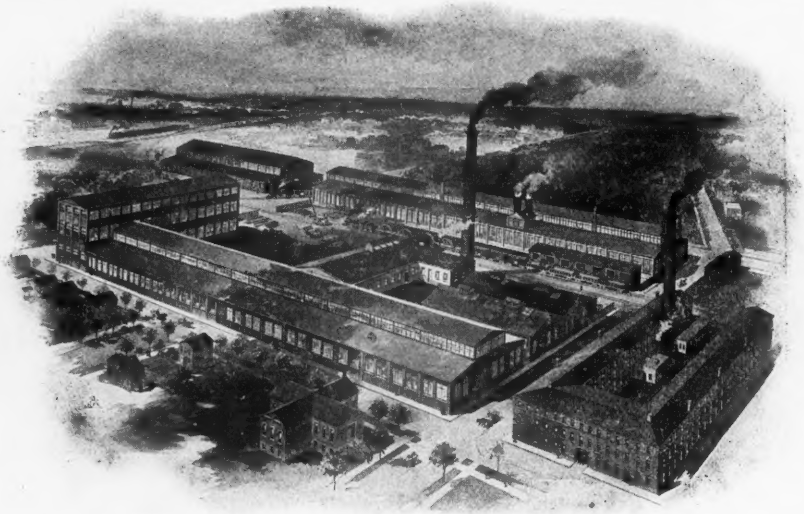

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ENGINEERING NEWS, 224 BROADWAY, NEW YORK

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

Vol. XII NOVEMBER, 1907 No. 9

THE ELECTRIC-AIR DRILL*

By William L. Saunders.

Many members of the Institute, who participated in the visit made, during the Bethlehem meeting of February, 1906, to the shops of the Ingersoll-Rand Company, at Phillipsburg, N. J., inspected with interest the new Electric-Air drill, which the company had set up for the purpose of showing it in actual operation to American mining engineers. At the request of the Secretary of the Institute, I promised at that time to prepare a paper for our *Transactions,* describing the construction and advantages of the machine. But such a paper would then necessarily have contained much that was only expected or claimed by the designers and manufacturers of the drill, and not yet incontrovertibly proved by varied and long-continued practice. However moderate such statements might have been, they would have given inevitably to the paper, to some extent at least, the air of a prospectus, rather than of a technical contribution. I therefore decided, with the Secretary's approval, to postpone the writing of the promised paper until it could set forth the results

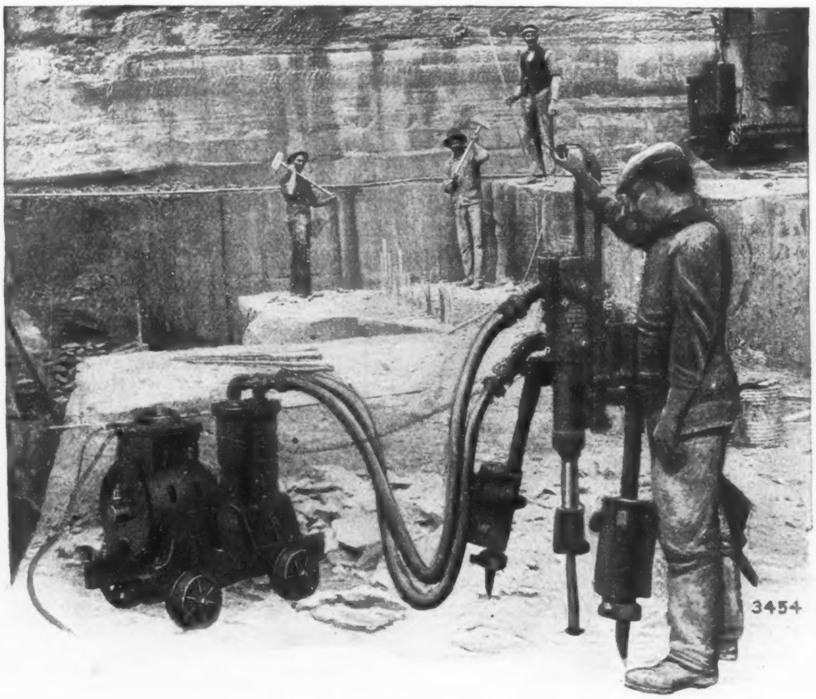


FIG. I. ELECTRIC AIR DRILL IN A QUARRY.

*Presented at the Toronto meeting, July, 1907, and reprinted from advance sheets of the Bi-monthly Bulletin of the American Institute of Mining Engineers for November, 1907.

of adequate actual practice, as well as the latest details of construction, etc., based upon practical experience. That period has now arrived. The Electric-Air drill has been exhaustively tested in the field, under varied and arduous conditions and upon the hardest rocks. It is now fairly in the field; its merits and performances are matters of unimpeachable record, and its place among established competitors can be definitely determined.

As a representative of the Ingersoll-Rand Company, as well as a member of the Institute, I may be permitted to add that my company, being largely interested in the manufacture of air compressors and machinery driven by compressed air, has no desire to injure its own business by claiming for this new machine that it should immediately supersede all existing applications of pneumatic transmission of power for drilling. On the other hand, if we had not satisfied ourselves that it has proved itself the best for given conditions, the company would not have risked its reputation by introducing it, and I, as a member of the Institute, would not have written this paper.

In former contributions I have discussed the use of compressed air, and opposed, to some extent, the claims of the advocates of electrical power-transmission in mining. I need not now retract any opinion thus declared. Many features of electrical transmission are undoubtedly convenient and economical; but the direct application of the electric current in rock-drilling has long been a baffling problem; of which, in my judgment, the machine here described has furnished the first, and thus far the only, satisfactory solution, by combining the acknowledged advantages of air-driven percussion with the acknowledged advantages of electric power-transmission, while avoiding the acknowledged disadvantages of both systems.

The Electric-Air drill is correctly designated; it is not an electric drill but an air drill, more completely an air drill than any other in existence, because it can be driven by air only and not like other air drills by steam also. Yet, while it is thus distinctly air operated the power of transmission is electric, and the sole connection of the drill with the power-house is made by means of the electric wire, air compressors and pipe lines being entirely superseded.

Fig. 1 gives a general idea of the apparatus. It shows a rock drill which at first glance looks quite like the familiar air or steam driven drill, mounted in the usual way and doing the same kind of work. Very near the drill and connected to it by two short lengths of hose is a small air compressor, or, more properly, a pulsator, mounted upon a little truck. This constitutes the entire apparatus of a single drill. Each drill is accompanied by its individual pulsator in the same way, and each pulsator is connected to the line of wire from the power-house.

The usual drill shell is employed and this may be mounted upon tripod, bar or column, according to the work. The drill cylinder fitted to slide in the shell is moved forward or backward by the feed screw. The cylinder is as simple as can be imagined; a straight bore with, at each end, a large opening and a boss to which to attach the hose. The piston also is plain, much shortened in the body, with a large piston rod, which has a long bearing in a sleeve elongation of the cylinder.

Upon the truck is mounted an electric motor, geared to a horizontal shaft with cranks on each end, which drive two single-acting trunk pistons, making alternate strokes in vertical air cylinders. One of these air cylinders is connected by the hose to one end of the drill cylinder and the other end of the cylinder is connected by the other hose to the other air cylinder. The air, therefore, in either air cylinder, in its hose and in the end of the drill cylinder to which it is connected, remains there constantly, playing back and forth through the hose according to the movements of the parts, being never discharged and only replenished from time to time to make up for leakage. The propriety of calling the apparatus a pulsator instead of a compressor is evident.

The essential details of the cycle of operation will be easily understood. We may assume, to begin with, that the entire system is filled with air at a pressure of 30 or 35 pounds. This pressure, being alike upon both sides of the drill piston, there will be no tendency for it to move in either direction. If, now, the motor, instead of being at rest, is assumed to be in motion, one pulsator piston will be rising in its cylinder and the other piston will be descending in its cylinder; and, as a consequence, the pressure upon one side of the drill piston will be increased and the

pressure upon the other side will be proportionately reduced, this difference of pressure causing the drill piston to move and make its stroke. Just before the drill piston reaches the end of its stroke, the movement of the pulsator pistons is reversed, preponderance of pressure is transferred to the other side of the piston, causing a stroke in the other direction, and so on continuously. The drill thus makes its double stroke, or at least receives its double impulse, for each revolution of the pulsator crank shaft.

This is a sketch of the general principle of operation; we may now consider some of the details. The drill cylinder, shown in Fig. 2, while generally similar to that of the air or steam operated drill, is in many respects quite different, and especially is it remarkable for its simplicity. The usual operating valve chest, the valve and the complicated means for operating it, the main air ports and the intricate little passages in and connected with the chest are all conspicuous by their absence, and nothing takes their place. The cylinder heads are both solid and both fastened securely in place. The split front head, the yielding fastenings for both heads, the buffers, the springs, the side rods, etc., of other drills are all banished. The cylinder is absolutely plain, with the boss at each end to which the hose is attached and the direct openings into the interior.

The piston also has been simplified. The rotation device is necessarily retained, but the enlargement at the end of the piston rod, which constituted the chuck and necessitated the split front head, is not. The piston rod throughout is much enlarged and a simple but effective self-tightening chuck is slipped on to the end of it.

The compressor or pulsator cylinders are as simple as the rest. There are no valves, either inlet or discharge, and there is no water jacketing nor the slightest need of any. The heating of the air upon the compression stroke is compensated for by the fall of temperature accompanying its re-expansion, so that the air does not get hot and does not heat any of the parts with which it comes in contact.

While this apparatus as a whole may appear complicated at first glance, it really is a great simplification, and the parts got rid of are those which have always been most troublesome and have entailed the most care and expense to maintain. The drill and the compressor or pulsator are each the simplest ever built.

There are some minor details of this apparatus with which it is not necessary to burden this paper and which would involve tedious explanation that all would not follow. In our description of the principle of operation of the drill we assumed a mean air pressure of about 30 pounds in the apparatus, and it may be asked how this pressure is secured and maintained. When the pulsator is in operation the air pressure in the cylinders both rises above and falls considerably below the mean, and at a certain point it is below that of the atmosphere, when, of course, a little valve provided will admit more or less air, this process continuing until sufficient air is supplied. In the beginning of operations the influx of air is rapid, so that no time is lost in getting sufficient pressure to begin with. The admission and also the apportioning of the relative vol-

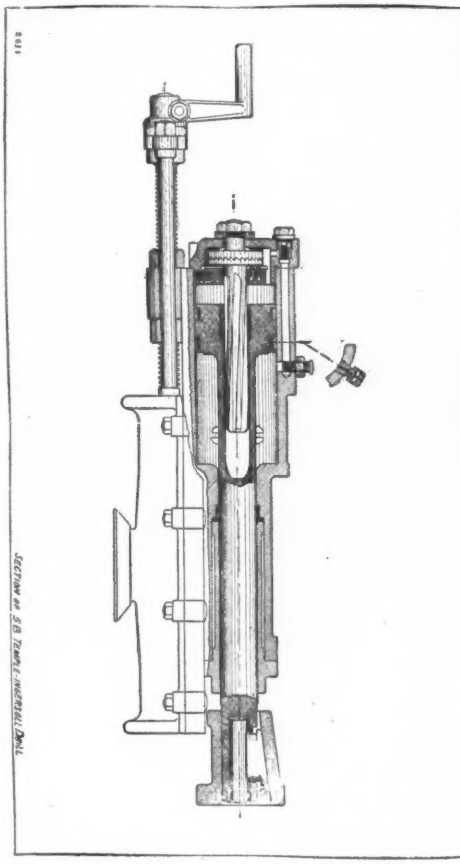


FIG. 2. SECTION OF ELECTRIC AIR DRILL.

umes of air to the two ends of the drill cylinder are easily adjusted by the operator.

With the Electric-Air drill there is no freezing up or choking of the exhaust, because there is no exhaust; the air also does not accumulate moisture and the temperature does not fall to the freezing point. The air does become and remains a constant vehicle for the conveyance and distribution of the lubricant, and with a certain amount of oil contributed to the system at regular intervals the problem would be how to prevent its reaching every working part rather than the reverse.

The length of hose employed seems to be limited to about 8 feet for each, and these may be attached to either side of the drill, but each always to its own end of the cylinder. This length of hose gives all necessary liberty for the location of the pulsator truck near the drill. The truck is of steel, with flanged wheels usually made for the standard 18-inch mine track, but may be made for any other gage. When in use there is no necessity for any care in leveling the truck, as the pulsator will work at any angle at which the truck can stand.

The motor may be either direct or alternating current, the latter being preferred because of the simple mechanical features. It is also smaller and lighter, a simpler and hardier machine and more nearly fool-proof. Four different speeds may be obtained with the direct current motor and two speeds with the alternating current, full speed for steady running and a considerably lower speed for starting a hole or working through bad ground, with immediate transition from the one speed to the other as required. The controller is on the top of the motor and the operator at the drill can start, speed or stop the motor by simply pulling a cord, this being the only connection. The electrical connection ends at the motor; both the hose and the cord insulate the drill and the operator is never exposed to the current.

The 5-C Electric-Air drill may be regarded as the full equivalent of the 3¼-inch standard air drill of any make; of its efficiency in comparison something will be said later. The power requirement for operating this drill is 18 to 20 amperes at 220 volts, or 9 to 10 amperes at 440 volts, the electrical equivalent of about 5 horse-power. The system being a closed circuit this is independent of altitude conditions, which make such a difference with the ordinary air drill, or, rather, with the work of the air compressor which supplies the ordinary air drill.

The 4-C Electric-Air drill, using a 3 horse-power motor, is a much lighter drill throughout and equivalent to a 2½-inch standard air drill. The table gives particulars of size, weight, etc., of both of these drills:

The dimensions and weights of the "Baby" or 3-C Electric-Air drill cannot as yet be made a permanent record. This drill takes the place and does the work of the "Baby" air drill.

The Electric-Air drill strikes a blow normally so much harder than that of the air drill of the same capacity, that in many cases it is found advisable to dress the steels blunter or thicker to avoid breakage. The practical force of the drill was not first worked out in computation, but has been demonstrated in extensive practice and protracted experiment. The explanation has come later, but is clear and sufficient.

The drill piston when running at full speed, making a stroke for each rotation of the pulsator crank shaft, will not strike either head. The hole by which the air enters the cylinder from the hose is not located at the extreme end of the cylinder, or close to the head, but a certain distance away from it, so that when the piston approaches the head a certain portion of air is enclosed and acts as a cushion which first checks the advance of the piston and then shoots it back. The piston thus starts upon its working stroke impelled by a certain amount of force which, we may say, has been saved over from the preceding stroke to be utilized for this. The piston after being thus started is driven forward by an air pressure which increases as it advances, the pulsator piston being in the attitude of chasing and gaining upon the drill piston for a considerable portion of the stroke, while in the case of the ordinary drill piston, driven by a constant flow of air which it runs away from, the pressure must constantly diminish as the piston speed is accelerated. In the same way by the action of the other pulsator piston the opposing pressure upon the advancing side of the drill piston is a diminishing pressure instead of the constant atmospheric resistance, and these combined cause a greater unbalanced difference of pressures upon the opposite sides of the drill, a more rapid acceleration of the piston movement and a consequent higher

velocity and force at the moment of impact of the steel upon the rock.

Perhaps the most gratifying, and also surprising, revelation of all in connection with the Electric-Air drill is the now indisputable fact that it takes only one-third to one-fourth of the power, at the power-house, to drive it to do the same work. This is accounted for by the fact that the same air is used over and over and that all of its elastic force is availed of in both directions, instead of exhausting the charge for each stroke at full pressure. There are also no large clearance spaces to fill anew at each stroke, as these spaces are never emptied.

A curious result of the mode of driving the piston of the Electric-Air drill, and another valuable feature of it when in operation, is found in the trick the drill has of yanking itself free when the bit sticks in the hole and going on with its work again. When the bit of the ordinary air or steam-driven drill sticks in the hole that is the end of it as far as the drill is concerned, and it is for the drill runner to free it as best he may. He runs the feed up and down, hammers the steel and coaxes things in various ways until the drill gets steadily running again. With the Electric-Air drill when the bit sticks the motor and the pulsator pistons do not stop, but keep running the same as before. This means that if the drill piston is making, say, 400 strokes a minute it will, when it sticks, receive per minute 400 alternate thrusts and pulls with full force. Nothing could well be imagined more effective for freeing the bit, and often when it sticks and before the runner can get ready to do anything about it the drill is running right along again as if nothing had happened.

DIMENSIONS, WEIGHTS, ETC., OF TEMPLE-INGERSOL ELECTRIC-AIR DRILLS.

	5-C	*4-C*
Diameter of drill cylinder	5⅝ inches	4¾ inches
Length of stroke	8 "	7 "
Length of drill, end of crank to end of piston	45 "	42 "
Depth of hole drilled without change of bit	24 "	20 "
Depth of vertical holes machine will drill easily	16 feet	8 feet
Diameter of holes drilled	1¾ to 2¾ inches	1 to 1¼ inches
Strokes per minute	425	460
Horse-power (at motor)	5	3
WEIGHTS		
Pulsator complete, with *direct*-current motor mounted on truck	883 pounds	585 pounds
Pulsator alone	271 "	160 "
Truck	102 "	100 "
Motor	400 "	275 "
Motor without armature	330 "	216 "
Armature alone	82 "	59 "
Controller, switch and rheostat	72 "	50 "
Entire equipment ready for shipment, including drill, Pulsator, direct-current motor, fittings, wrenches and extra parts, but not mountings, steels or blacksmith tools	1680 "	902 "
Pulsator complete with 30 or 60 cycle *alternating* current motor mounted on truck	630 pounds	360 pounds
Pulsator alone	271 "	160 "
Truck	102 "	100 "
Motor	202 "	137 "
Motor alone	46 "	34 "
Controller switch with base	45 "	45 "
Truck cross bars for motor	15 "	15 "
Entire equipment ready for shipment, including drill, Pulsator, 30 or 60 cycle alternating current motor, fittings, wrenches and extra parts, but not mountings, steels or blacksmith tools	1080 "	680 "
Tripod with weights	540 "	430 "

NOTE: Weight of column and shaft-bar mountings will vary with their length and diameter.

The coming of the Electric-Air drill suggests many possibilities and ominously means much to the established interests. It necessarily suggests a revolution in methods and sometimes perhaps a superseding of the old plants throughout. In the working of the new drill the old central air compressor plants are absolutely worthless, but it is not easy to imagine any general abandonment of them. After all, the result may probably be that the new drill will not, to any great extent, drive out the old, but will make a new field of employment for itself, and in that way lead, as usual, to a considerable enlargement of the already extensive business which is behind it.

As has been shown, the Electric-Air drill is as far as can be from being an electric drill, but it makes the ordinary electric current nearly everywhere obtainable immediately available for driving it.

In the planning of installations which are new throughout, the Electric-Air drill is to be most seriously considered. The question of the relative final cost of operating this drill, or any other, is, after all, the decisive one, due recognition being given to the peculiarities of each, favorable or otherwise, which are not computable but which still have their weight in determining our selections, "other things being equal."

When the Electric-Air drill is operated without its own generating plant, the current being taken from a large power company, some very low figures are already on record. At Idaho Springs, Colo., a mine shaft was put down 67 feet in twenty-four shifts and the total power cost was $24 for the entire work.

In making rock excavations for building purposes in New York City and elsewhere, steam drills, having a temporary boiler installation, are frequently used. The Electric-Air drill not only avoids the expense of the boiler equipment but will do the work at a much lower cost, the current being supplied by one of the big electric power companies.

MACKELLARITE AND STRANLEIGHITE ENERGY

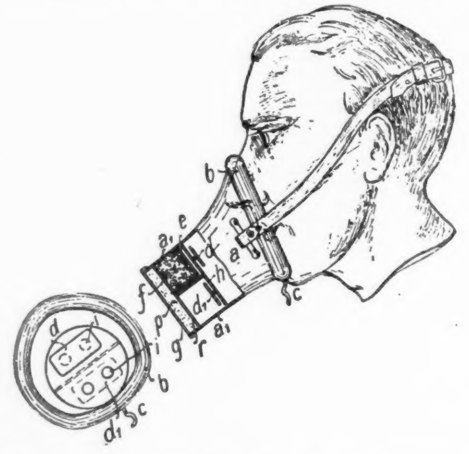
"Mackellar, there is one characteristic which I do not like about you. Perhaps, it is oversensitiveness on my part, but it sometimes seems to me that you think I am lacking in energy. I may find it difficult to put your mind right on this subject. Let me give you an illustration, chosen from your own interesting profession of mining-engineering. I am credibly informed that if a hole is drilled in a piece of hard rock, and a portion of dynamite inserted therein, the explosion which follows generally rends the rock in twain."

He paused, and there was no reply. Unabashed, his lordship proceeded:

"That is energy, if you like. Shall we name it a Mackellarite form of energy? Now I shall tell you of a thing I have seen done on one of my own estates. A number of holes were bored in a large boulder, and instead of dynamite, we drove in a number of wooden pins, and over these pins we poured placidly clear, cold water. After a time the rock gently parted. There was no dust, no smoke, no flame and fury and nerve-shattering detonation, yet the swelling pins had done exactly the same work that your stick of dynamite would have performed. Now, that also was energy, of the Stranleighite variety. I suppose it would be difficult to make a stick of dynamite understand the stick of wood, and *vice versa.*—*Saturday Evening Post.*

DUST MASK FOR ROCK DRILLERS

The mask illustrated in the drawing has been in use for some time at the Katharina shaft of the Herkules Colliery, near Essen, for protecting the rock drillers from the dust produced by the powder drills. It consists of a conical sheet metal casing, *a*, extended at one side into a cylindrical attachment, a_1, and fitted round the other end with a tubular rub-



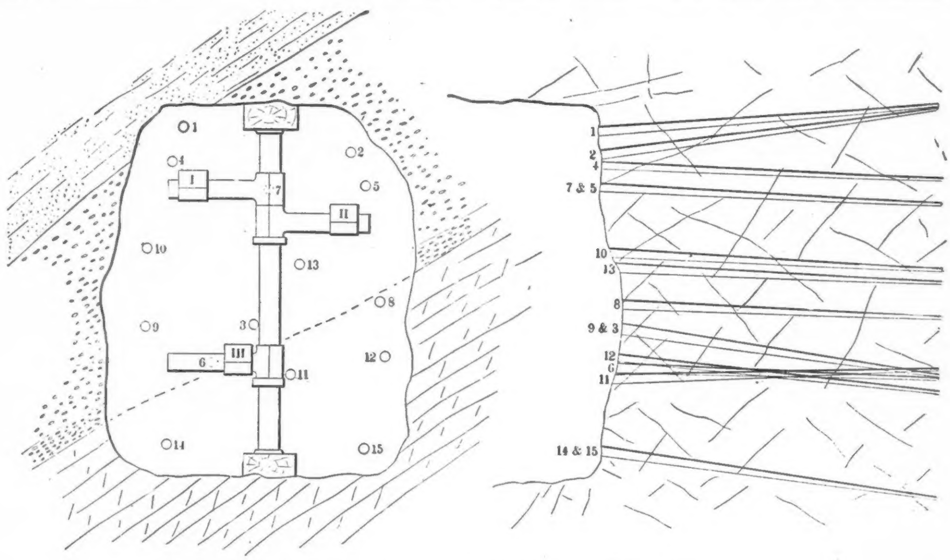
ber pad, *b*, which can be inflated through a small rubber pipe, *c*, in order to make a dust-proof joint all round against the face of the wearer. The thin iron partition, *h*, in the cylindrical attachment, a_1, is provided with four apertures, *i*, which are covered by two rubber flaps, *d* and d_1, serving as valves. The upper flap, *d*, is mounted on the side next the wearer's face; the bottom one on the lower side of the partition, *h*, so that the two open and close alternately during inhalation and expiration. The upper part of the cylindrical attachment, traversed by the incoming air, is occupied by a sponge, *f*, mounted between a front and back plate of wire gauze, *e* and *r*, the latter being covered with a loose stratum of cotton waste, *p*, to absorb the dust. The

front of the mask is covered by a third plate of gauze, *g*. For use the mask is fitted over the mouth and nose, and fastened over the head by straps, as shown in the figure. It appears to act satisfactorily, and the men like to wear it.

MULTIPLE ARRANGEMENT OF DRILLS ON THE RAND*

In the Cinderella Deep Mine in the Transvaal the system of using three machines rigged on one bar, in pushing forward an ordinary 7x5 foot drift, was introduced by Manager Girdler Browne. The use of this method established a record, on the Rand, for rapid driving, and this was performed at a depth of over 4,000 feet. I believe some American tunnels have been advanced at a greater rate, and I should be glad to hear from any correspondent on the subject. The advance was 225 feet in a month of thirty-one working days. Three men with five or six natives and sometimes a white assistant, worked in eight-hour shifts. Compressed air was freely used for blowing out the smoke, and the rock was wetted after a blast. As soon as the rock was sufficiently shoveled back from the face the miners returned, set up the drills and started drilling while the rest of the rock was being removed. The rock had to be trammed 500 to 800 feet. The best previous drifting record was in the Roodepart district, in soft ground requiring only nine holes per round. The distance driven was 220 feet in one month.

On the Cinderella Deep the quartzites, forming the hanging wall of the banket reef, are very hard. The reef itself is of moderate hardness and the dark quartzites or quartzose slates, under the reef, are fairly soft. The illustration shows a normal face bored out with fifteen holes. When the drive gets more into the hanging wall more holes may be required. Four or five holes may be necessary on either side and perhaps other easers. The bar, which is usually a "double-jack" bar, is rigged as securely as possible about 4 feet from the face. One arm is rigged, as shown, to put in a flat hole in the hanging wall; another is fixed directly below this to bore the roof-hole on the other side of the drive. Safety clamps are put on under these two arms and also under the bottom arms. The third arm is rigged lower down to bore the top hole of a three-hole cut. This is generally put in to take advantage of the contact between reef and footwall. The two dry holes and the cut hole are first slated and then the holes of the face are bored in the rotation shown by the numbers on the drawing. The top machines drill the shoulder holes, No. 4 and No. 5, without altering the arms.



MULTIPLE MOUNTING OF DRILLS ON THE RAND.

*Edgar Nichols, Mining Engineer, Brakpan, Transvaal, in Engineering and Mining Journal.

No. 1 machine drills holes 1, 4, 7, 10; No. 2 machine drills holes 2, 5, 8, 11, 13; No. 3 machine drills holes 3, 6, 9, 12, 14, 15.

Though No. 1 machine has only four holes to drill, the flat hole in the hanging wall takes so long that it is not finished much before the others; the No. 2 machine has all water holes to bore and should be rigged under the arm drilling the lifter holes 14 and 15 before No. 2 machine comes down to drill hole No. 2. No. 2 machine has hole 13 to drill after No. 1 has drilled hole 10. If possible No. 1 machine is not given more to do after it has bored hole 10, as it is almost impossible to work with all the arms low down on the bar. Very often when the footwall ground is soft No. 3 finishes first and it can then be used to collar holes for the other machines. In the same way Nos. 1 and 2 machines can cross-collar difficult holes for each other. About four 1¼-inch sticks of blasting gelatin are placed in each cut hole and from five to six in the other holes. The cut is blasted first, then the easers, then the shoulder and knee holes, then the back holes, and lastly the lifters. No. 8 hole is run in under the contact of reef and footwall to prevent any lump being left on the side of the drift. The drift is run at a grade of one in 150 to 200 and has a single track with sidings every few hundred feet. It is considered quicker to run the drive 5x7 feet, as shown, and to use a single track only, than to take the drive out full width for a double track and to rig four machines. For a long drive the drift is squared off by hand labor to allow of a ventilating pipe being laid along the track. Before the regular work of stoping is started the drive is widened out and double tracks are put in.

Several of the Deep mines are installing monorails for tramming, the Langlaagte Deep mine being the pioneer in this work. It is hoped that, by using rails suspended 4 or 5 feet from the floor on iron brackets, friction will be much reduced and that the installation of some system of mechanical haulage will be rendered practicable. The air pressure employed in the Cinderella Deep was about 80 pounds per square inch. Machines with 3¼-inch cylinders were employed; combination piston and slide-valve; star-section welded steel bits, up to 5-foot lengths and longer lengths of chisels were employed. The diameter of starter bits was from 2¾ inches to 3 inches and the difference in gauge about 0.25 inch.

HOT AIR FOR DRIVING FANS

E. H. Dennison, in *Consular Reports*, says that a German firm has recently introduced at Bombay a portable fan driven by a hot-air engine which is destined to have a large sale throughout India. He says that owing to the intense heat which prevails in that country during most of the year fans of some kind are a necessity to the comfort of Europeans, and their offices, shops, and residences are all equipped with the old-fashioned swinging screens known as "punkahs," which consist of a piece of cloth or matting stretched over a rectangular frame hung from the ceiling and kept in motion by a servant at the end of a cord. Wherever electricity is introduced these are generally superseded by electric ceiling fans.

The natural field for the hot-air engine fan would be in localities where there is no electric power, but it has been found that it can compete with the electric fan in the latter's own field, owing to the extreme cheapness of the cost of its running, which is about one-fifth of that of the electric fan.

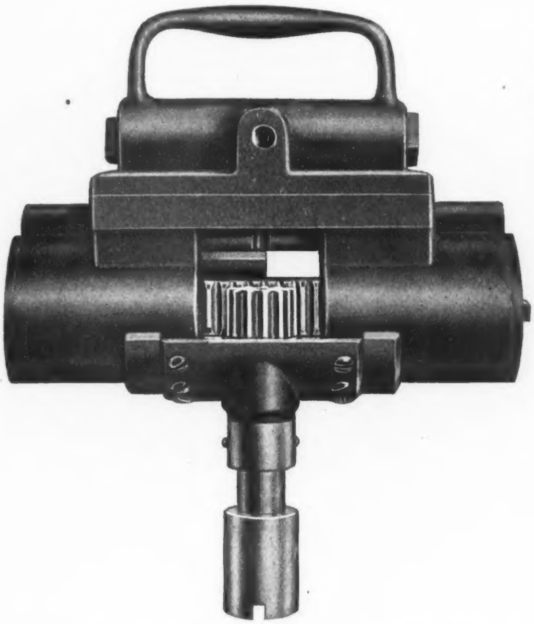
The fan is propelled by a hot-air engine, the heat being generated by a kerosene lamp which holds about 1 quart of oil, sufficient to keep the fan running for over twenty-four hours. To the lamp is attached a small glass chimney which fits into a larger metal chimney connected with the engine. Upon the top of the engine is hung the fan, similar in shape and size to the ordinary electric fan, whose speed is governed by the size of the flame; that is, to reduce the speed the flame is turned down, and to increase it the flame is turned up. The whole outfit weighs about 30 pounds, and sets upon a small stand, raising the level of the fan proper to that of an ordinary desk.

If American manufacturers can produce a similar article, with perhaps a few improvements and at a smaller cost, an immense field will be found for its sale, for this is not necessarily limited to India, but would include every hot country in which white people are compelled to live.

These fans at present sell for $62 each, which makes them rather too expensive to be used by any but the well to do. However, the manufacturer expects to soon be able to materially reduce this price with the expected larger output.

A PNEUMATIC OSCILLATING VALVE GRINDER

The tool here shown will at once appeal to the man of the shop. So far as known, it is the only one of its class, and in its advent it at once supersedes hand labor for an important operation. The grinding and regrinding of valves for pumps, air compressors, gas and gasoline engines, and angle, check and other valves of metal, is a frequent and familiar job, and up to the present time it has been done almost entirely by hand, because it will not



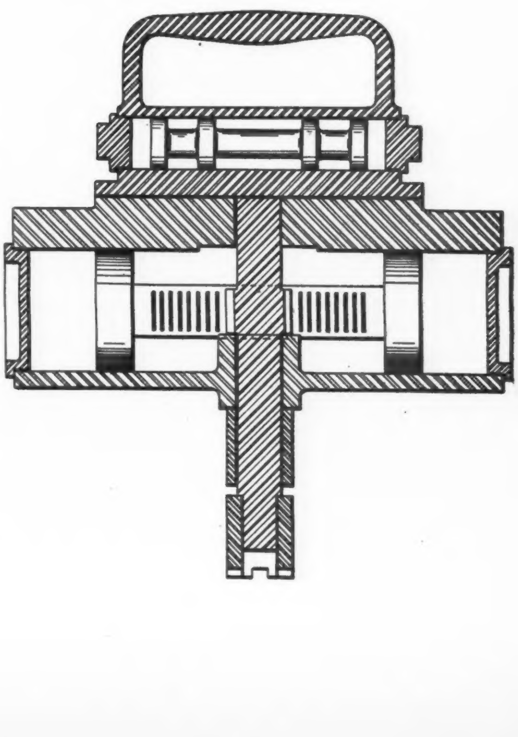
permit continuous rotation. The valve must be turned back and forth or the seats will be scratched and scored instead of being smoothed by the grinding.

This tool does the trick continuously and automatically and requires no explanation. A rack with a single-acting piston at each end of it works back and forth, and meshing into a pinion on the spindle produces the intermittent and continuously reversing rotation. A single spool valve comprises all the other mechanism. The size of the grinder is 9 x 10½ inches and it weighs 14½ pounds. Air connection is made through ¼-inch hose nipples. Chucks or drivers can be fitted according to the style of valve to be ground.

When desired a rigging may be used to support the grinder, consisting of a bar attached to the body of the driver near the handle and pivoted at one end to a stationary support. Then by raising or lowering the other end, the grinder may be properly applied to the work and the pressure regulated as desired. The grinder is made by the Cleveland Pneumatic Tool Company.

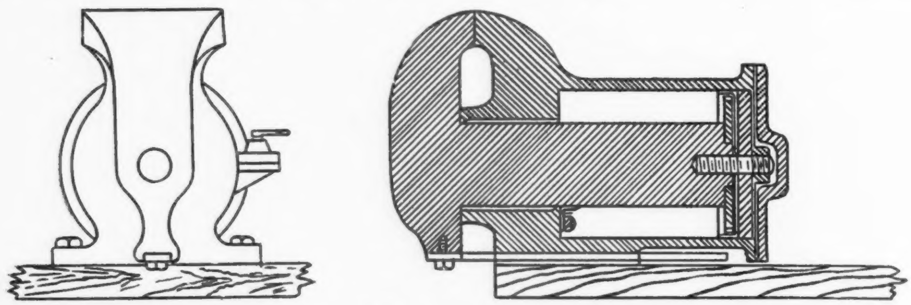
An interesting use to which gypsum is put, especially in England, is the *burtonization* of beer. The reputed excellence of certain British beers, notably those of Burton and Newark, is attributed to the presence of calcium sulphate in the natural water used in their preparation. It has been calculated that 350,000 pounds of gypsum are annually imbibed in potations of Burton beer, and since gypsum is soluble to a certain extent, attempts have been made with varied success to add similar artificial salts to water not derived from gypsum-bearing beds, and large quantities of gypsum are purchased by brewers in England for this purpose. This addition, although advantageous, does not produce so perfect a combination of salts as that existing in the natural waters of Burton-upon-Trent.

Each horse-power used for manufacturing in Pennsylvania produces annually an average of approximately $1,000 worth of goods, according to a bulletin issued by the McCall Ferry Power Company.

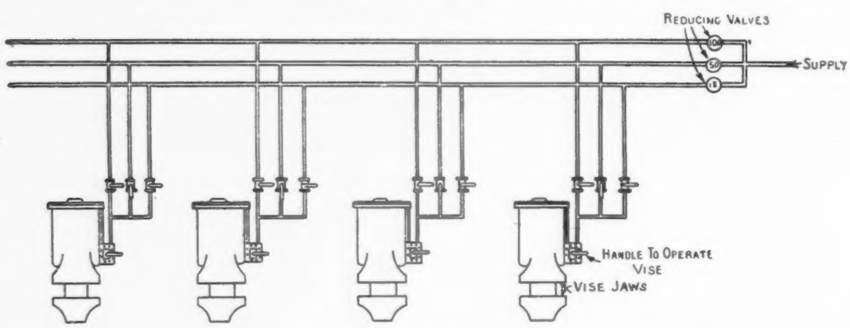


AIR-OPERATED VISE

The cuts on this page, taken from *Railway and Locomotive Engineering*, show a compressed-air-actuated vise, invented by Mr. J. E. Osmer, Master Mechanic of the Northwestern Elevated Railroad of Chicago. The action of the vise is simple and scarcely requires explanation. In the size of vise most used the working cylinder is 7 inches in diameter and the rod 4 inches, and with 100 pounds of air pressure the grip is 2,590 pounds. A guide at the bottom prevents the rod and jaw from turning. To open the vise no additional air is required. There is a run-around passage at the side of the vise and a little valve opens communication with the back of the piston, and when the air is thus admitted to the larger piston area the difference forces the jaw out as required. Not more than 1/8-inch piping is required for the largest size, and the air consumption is inappreciable in a shop where a constant air supply is maintained. By piping up as shown in Figure 2, with reducing valves giving different pressures, either pressure may be used at will according to the grip required. For three pipes and three different pressures, as shown, of course only two reducing valves would be required.



AIR OPERATED VISE.



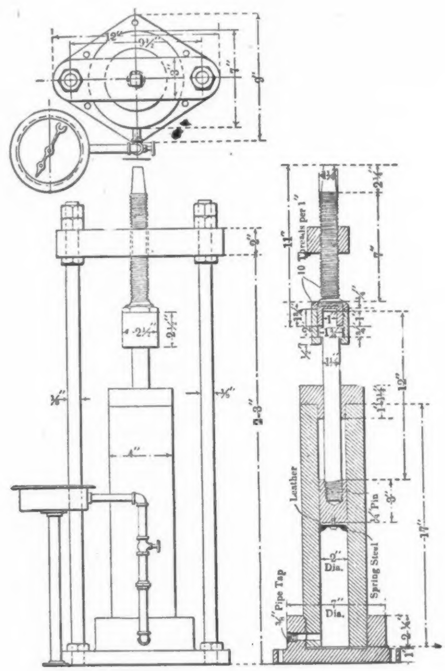
PIPING FOR AIR VISE.

A MECHANIC PRIEST

Near the northern coast of France, on a route much frequented by motorists, lies the village of Graincourt. Here a beautiful little church is set high among the trees. Close by is the home of the priest, and around it a strange litter of bicycles, motor-cycles, automobiles, oil-cans, and tools, while the open doors reveal on one side a kind of garage, on the other a repair shop. From this building, as the tourist approaches, comes a tall figure, with the body of an athlete and the head of a missionary, and muscular arms bared to the elbows. This is the curé of Graincourt, who is now village mechanic as well. His father was a smith, and he grew up with a passion for tools. When the bicycle came in he became an amateur specialist. Then came the motor-car, which won the heart of the curé. He loves it, and thinks he understands it. He has even built a car and a motor-cycle for himself. And so the fame of the mechanical curé of Graincourt has gone abroad throughout all the country, and at last he has decided, without any scruple, to make a business of what had formerly been a pastime.

A TESTER FOR PNEUMATIC DRILLS

The cut, which we reproduce from the *American Engineer and Railroad Journal,* shows the details of a device for testing the torque of rotative pneumatic drills in use in the tool room of the McKees Rocks shops of the Pittsburg and Lake Erie Railroad. The top of the main screw of the apparatus is



TESTER FOR PNEUMATIC DRILLS.

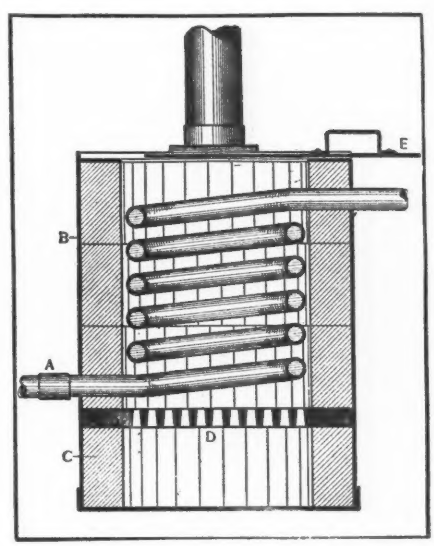
square and the spindle of the drill to be tested is applied to it by means of a suitable chuck. As the screw descends the piston in the cylinder below produces a pressure upon the oil and when the drill is stalled the pressure is noted on the gauge at the side. It is said that different makes of drills guaranteed to be of the same power have shown a range of from 1,800 to 5,500 pounds. When a new drill is received it is tested and a record is made of its capacity. When the drill requires repairs or any complaint is made it is tested to determine whether its capacity is still normal, and after repairing it is tested before it is handed out. The records made are, after all, only comparative, but they are sufficient for practical service.

A CHEAP REHEATER

The little engine, driven by compressed air, of which I have charge, is a long distance from the compressor (3,000 feet) and thus the heat produced by compression all escapes before the air reaches the engine.

When first started, the engine would run all right, but after it had been running a few minutes the valve would work stiff and the link would begin to quiver. Then the piston would groan, and after running irregularly for a little while the engine would stop altogether and all the pressure we had wouldn't move her an inch until the cylinder was thawed out.

In order to overcome this difficulty and at the same time to expand the compressed air, I built the reheater here shown, which successfully prevents the engine freezing up and materially reduces the consumption of air.



A CHEAP AIR REHEATER.

A piece of 1-inch pipe was coiled as shown at A, and enclosed in a sheet iron casing, B, having lap joints riveted together. This was lined with fire brick as shown at C, and provided with a circular grate, D. The fuel is put in from the top, which is covered by a sliding lid, E, of sheet iron. Another sliding door, not shown in the sketch, is placed at the bottom to allow the removal of ashes and to regulate the draft.

This reheater has been so successful that we now run it all the time; even during the warm-

est weather when there is little danger of freezing, the object being to reduce the amount of air used. The engine develops 12 horse power with 85 pounds air pressure.—*A. E. Scheetz, Trevorton, Pa.—Popular Mechanics.*

COMPRESSED AIR AND THE KINETIC THEORY OF GASES*

To the ordinary consumer of compressed air it serves simply the purpose of an energy reservoir and for power transmission. Its utilization in this field is so efficient and it is so easily obtainable that it is doubtful if it will ever be replaced by any other material. In reality, however, the general viewpoint of compressed air as an energy reservoir is fallacious—compressed air contains no more energy than ordinary air. Compressed air is simply air which has been compressed to a higher pressure and the laws which govern it are simply those which hold throughout in the kinetic theory of gases. According to this theory, a gas is made up of individual molecules flying around through space like small projectiles, colliding and re-colliding with each other and with the walls of containing vessels. The summation of this series of blows on a surface constitutes what is known as pressure. The real meaning of temperature is absolutely unknown, but it is known that absolute temperature to-day is directly proportional to the mean kinetic energy of these small projectiles or molecules.

To show that the first statement in regard to compressed air as an energy reservoir is true, all we need to consider is the fact that the temperature, if not identical with, is at least proportional to, the energy of the molecule. When a gas is compressed the molecules are given an increased amount of kinetic energy. This means that they are raised in temperature by compression. If the gas now under pressure is allowed to cool off to normal temperatures it thereby loses the energy which has been put into it and which has become apparent as an increase in temperature. Each molecule possesses precisely the same kinetic energy as before compression, and in a gas, unless extreme compression is accomplished, the molecules still remain at a distance sufficiently apart to have no influence on each other. Hence the total kinetic energy in the gas under compression is identical with the total kinetic energy in the gas before compression. Of course, the energy has been concentrated in amount per cubic foot, but if this gas were allowed to expand in a cylinder without access to the outside air, or, rather, without thermal connection with surrounding bodies, little or no work could be obtained from it.

*Abstract of Paper by J. H. Hart in October Power.

COMPRESSED AIR MERELY TRANSFORMS ENERGY.

In reality, a gas under pressure, when it starts to expand, loses some of its energy to the piston. It then possesses a smaller amount of mean kinetic energy per molecule, and is therefore at a lower temperature. It is immediately raised by the surrounding atmosphere, or containing vessel, to normal temperature, and can then continue doing work at this higher pressure, and the process continues until the pressures on both sides of the piston become equal. From this it is evident that compressed air is not a reservoir of energy in any form. Compressed air expanded freely into a vacuum does absolutely no work and does not cool off or lose energy.

This becomes evident when the compression on a pressure-volume diagram is considered. Every engineer knows that the curve which represents adiabatic compression is steeper than the curve representing isothermal compression. Of course, the object in compression is to get the curve as near isothermal as possible in order to diminish the amount of work necessary to produce the compression. Hence, we have three-stage compressors in which the gas is compressed adiabatically, then cooled off to the temperature that it would have had if compressed isothermally, and the process repeated twice, giving three stages. This results in an increased efficiency of production, but since the processes are identical in action, only one—that of the single-stage compressor—need be considered. In this the compression is generally adiabatic, then the curve drops vertically to the isothermal point as the gas cools off and the pressure diminishes on this account without change in volume. At this point in the diagram, however, the gas has reached another adiabatic curve passing through this point so that the total change in the gas is in reality simply a change in pressure, volume and entropy, whatever the latter may mean.

KINETIC THEORY CLEARS UP COMPLEX POINTS.

There is no doubt that a capable treatment of the subject of compressed air from the

standpoint of the kinetic theory of gases elucidates many complex points and renders clear much that is otherwise obscure. This conception of the energy in compressed air explains clearly the inability to utilize it in free expansion. In the transference of energy from place to place, through long pipes, this is carried on by a series of bombardments from molecule to molecule and explains the time taken in transmission and the loss of energy, or the diminution in pressure, which results when the transmission is long. It enables the engineer to understand clearly what occurs in compression and what is meant by the different kinds of compression. Thus, adiabatic compression means compression in which heat, as such, does not pass to or from the air or gas in the containing vessel. Every time molecules are hit by the piston they are forced to rebound and given an increased energy. This energy is not lost in adiabatic expansion to the walls of the containing vessels, but is present when the molecules collide with the piston a second time. It explains by this reasoning the manner in which the pressure rises abnormally over that in isothermal compression.

In this latter the molecules rebound from the piston with an access of energy, but this is lost by transmission to the walls of the containing vessel before they collide again; hence the pressure does not rise abnormally over what it should theoretically be. In this respect the pressure depends simply on the force with which each molecule strikes, the number of times it strikes a second, and the number of molecules which hit per square inch of surface.

When a gas is compressed more molecules are contained in a given space, hence the bombardment increases both on account of increased number of molecules striking and on account of increase in number of times of striking per second. This explanation completely satisfies and explains the behavior of a gas in its relation to pressure and volume and also explains deviation from this relation, known as Boyle's law, and does it accurately and efficiently, so that theory is completely in accord with practice. In general, the kinetic theory of gases is the only thing that completely explains the behavior of gas under all conditions and, further, it not only does this but it has foretold many phenomena previously unknown and these have been verified by experiment.

There is no doubt that a study of the kinetic theory of gases completely elucidates many of the obscure points (and in fact all of them) in the conception of the compression of gases, if it is investigated sufficiently. Of course this is work primarily for physicists, but engineers are daily becoming more and more interested in physical science and it is absolutely necessary to-day that a compressed air engineer, or manufacturer, or even the consumer, should know enough of this development to understand the phenomena which are going on inside of the compressor. By this means reheating, and the reason for the increased efficiency obtained thereby, become simple and clear. The presence of moisture in the air and its effect on the efficiency also are easily understood.

VALVE ABUSES AND TROUBLES CONSEQUENT

A writer in the *Valve World* says that at least 90 per cent of the trouble with valves delivering water or steam—to which compressed air might of course be added—arises from the improper use of cement, and from a failure to remove the particles of cement, scale, chips, dirt, etc., which get into the pipe while it is lying around a building and lodge on the valve seat after steam or water is turned on. Cement should be applied on the male part only, for if placed on the female part it is likely to go through the pipe and land on the valve seat. Besides this, in nearly all cases more cement is used than is necessary.

Frequently, when a valve leaks, which is usually due to the presence of dirt in it, some one tries to tighten it by using a lever on the wheel. This nearly always injures the valve. It is much better to take the valve apart and clean the seat. Similarly, when a stuffing box leaks, attempts are often made to stop the leak by straining the stuffing box with a large wrench, when the real trouble is that the packing has become worn and needs renewing.

One of the common abuses is the use of a wrench on the opposite end of the valve from that which is being screwed on the pipe. This is particularly bad with light valves, as it is almost certain to spring them and cause them to leak. Again, with light valves, when placing them in a vise to remove the center piece, the valve should always be clamped lengthwise. In removing the center piece care should be taken to have the disk some distance from the

seat; otherwise it will be forced down upon the seat and some part will become strained. Another trouble likely to occur in a line containing light valves results from failure to make proper allowance for expansion. The pipes and fittings are much more solid and rigid than the lighter brass valves, and the expansion strains will mainly affect the latter, unless proper allowance is made.

LUBRICATION OF AIR COMPRESSOR CYLINDERS

The occasional occurrence of fire in air compressor cylinders is due to oil, which is the only substance present that can burn, and the cause of this difficulty cannot be laid to the oil alone, although it is well known that an inferior oil can readily cause explosions.

That certain structural features of a given machine may facilitate or retard combustion of the oil will appear from what follows, and the fact of an air compressor drawing the air from whatever location it may be in, naturally necessitates the presence in the air cylinder of whatever foreign substance there may be in the atmosphere, as, for instance, in acid or alkali works, coal mines, copper mines, or other places of a similar character, where air is being drawn into the air passages of the machine. This combines with the excessive amount of residuum, or carbon left behind and through oxidation forms a substance for fire to feed on, the fire resulting from causes herein set forth.

The greatest amount of oxidation takes place at the point where the air passes from the cylinder into the discharge pipes, and through continued deposition decreases the size of the mouth of the discharge pipe, and more air is compressed in the cylinder than can pass through the discharge pipe, resulting in the recompressing of the air and an increased amount of friction, also an abnormal degree of heat in the air cylinder.

Oil should be of such quality as to cause the least oxidation possible, and the flash point should be as high as good lubricating qualities will permit. The flash point of oil is that degree of heat at which some constituent part of the oil passes off as vapor, which, being inflammable, will ignite if brought into contact with fire.

The mere raising of the temperature of an oil to its flash point will not produce ignition. Another cause must be presented to produce ignition of the vapor. Indeed, such a cause may operate before the flash point is reached, as in the case of sawdust saturated with linseed oil. Such a case is, according to my experience, oxidation of the oil. Combustion, so far as I have to consider it, is in this case, the rapid union of a substance with oxygen in the presence of a flame. There can be, of course, repeated oxidation without flame, but if the action be sufficiently repeated, heat enough will be generated to set the substance on fire, and if a considerable quantity of inflammable vapor be present, an explosion is likely to follow.

The engineer can prevent a crankpin or a crosshead pin or any other accessible moving part of the compressor from getting hot, but when it comes to keeping the heat out of the air cylinders or discharge valves the only way he can do it is by using high flash point oil in connection with a good water jacket around the cylinder. The engineer does not always get the right kind of oil he ought to have, for most of the companies buy oil as cheap as they can get it. It is true it is cheap in the beginning, but it is always the dearest at the end of the month or year.

Kerosene should never be used in an air cylinder, but, instead, fill the oil cup with soap suds made preferably of soft soap, one part soap to 15 parts water, and feed this into the air cylinder. Let the compressor work with soap suds instead of oil for a few hours, or say a day each week. Feed the solution liberally and then open the receiver blowoff and drain off the accumulation of oil and water.

This cleaning process should be repeated as often as necessary, the exact intervals depending on the service of the compressor. If running at full capacity for 24 hours a day, about once every week or two will be sufficient. If on a light load and running for eight or ten hours per day, once every month or two will do very well. The soap suds can do no harm, but care should be taken to feed with oil a half hour before shutting down so that the parts may not be subject to rust, which is the only danger from the use of soap suds.

Ignition in compressed air discharge pipe and passages is not uncommon, and at times this ignition is in the nature of an explosion. Two air receivers were blown up during the

construction of the New York aqueduct and in one case the engine room was destroyed by fire resulting from this explosion. I witnessed an air receiver explosion recently when four men were badly injured and the air receiver was blown to pieces and thrown from the foundations. The cause of this explosion was the using of oil having a very low flash point. Ignition took place near the air compressor, the pipes becoming red hot at the joints.

This ignition has been known to extend into the air receiver, and in one instance the flames were carried down into the mines by the compressed air. In all these cases a large volume of compressed air was used, and it is plain that the explosion or ignition was due to an increase of temperature above the flash point of the oil. Steam cylinder or engine oil which is thick and gummy should never be used in an air compressor.

I know, however, of an instance where ignition took place with oil which had a flash point of 575 degrees F. and the ignition point 625 degrees F. The conditions were similar to those mentioned; that is, the air was compressed to about 60 pounds per square inch, gage pressure. If the temperature of the air before admission to the compressor is 60 degrees F., and it is compressed to 58.8 pounds gage pressure, the final temperature where no cooling is used during compression, will be 309.4 degrees. If air admitted at 60 degrees F., is compressed without cooling to 73.5 pounds gage pressure, the final temperature will be 414.5 degrees F. and the total increase of temperature 354.5 degrees.

Under such circumstances the question arises, how is it possible when using oil with an ignition point of over 600 degrees to get an ignition, especially as water jackets and other methods of cooling are used which should reduce the final temperature? The figures are also based on dry air, which increases in temperature to a greater degree than moist air, and it is known that air which is used in compressors is never very dry. The theoretical figures show that in order to get ignition with the oil mentioned, the gage pressure should be about 200 pounds per square inch. Where a cooling takes place it is plain there must be an increase of temperature, or ignition would not take place. This increase of temperature may result either from an increase of pressure which is not recorded on the gage, or there may be an increase of temperature without a corresponding increase of pressure. Take the first instance, and it is not difficult to understand that an air compressor might deposit carbon from the oil in the discharge passages or discharge pipes, which I found out to be the case, which in the course of time will accumulate and obstruct the passage so that they do not freely pass the volume of air delivered by the compressor, hence a momentary increase of pressure exists on the cylinder heads or in the discharge pipes which lead from the air cylinder to the receiver. This momentary increase of pressure would surely carry with it an increase of temperature which might exceed the ignition point of the oil.

A badly designed compressor with insufficient discharge passages will produce this trouble. Too small a discharge pipe will also tend to produce explosions, but I know instances where ignition has occurred in a well designed system, hence we must look for other causes. A hot engine room from which air is drawn into the cylinder is a bad condition. I know of a plant where the incoming air was drawn from the neighborhood of the boiler room, the temperature being close to 150 degrees. When air is compressed to 73.5 pounds gage pressure it is 345.5 degrees. The temperature of the initial air should be added to this figure and then the final temperature might be 504.5 degrees.

Ignition has taken place when the temperature of the incoming air was normal, and when the discharge passages and pipes were free and of ample area, hence we must look for some other cause. The only possible explanation that I make is that the temperature of the incoming air is made excessive by the sticking of one or more of the discharge valves, thus letting some of the hot compressed air back into the cylinder to influence the temperature before compression. When a piston of an air compressor has forced a cylinder volume of air through its discharge valves, and when this piston has its direction of movement reversed, there will immediately be a tendency of the air just compressed and discharged to return to the cylinder. In this it is checked by the discharge valves, but through long and constant use these discharge valves become incrusted with carbon and are not free to move.

I overhauled a compressor not long ago and found the discharge valves so incrusted with

carbon that the only way I could take them out was by driving them out with the handle of the hammer. These valves had not been cleaned for ten months, and this was a case where the engineer either did not know how to clean them or did not care to do it, hence there was a moment when one of these valves stuck and did not seat properly. In either case there will be some hot compressed air in the cylinder, when the piston starts on the return stroke of compression. It is not difficult to understand how a leaky discharge valve will let enough air back into the cylinder to increase the initial temperature to 200 or 300 degrees. If so, and we are compressing air at 73.5 pounds gage pressure, we have, say, 300 degrees temperature in the free air before compression, and as the increase is 354.5 degrees, this will require frequent cleaning of the discharge valves and passages.

Continuing the important subject of explosions in compressed air passages, even with the best form of discharge valves, trouble may arise because of the use of bad oil or of *too much good oil.* Engineers are apt to suppose that an air cylinder of a compressor requires oil just as much as the steam cylinder. This is a mistake.

To obtain best results use oil in the air cylinders running at 40 to 50 revolutions at a rate of 1 drop per minute, which is plenty. Over 50 revolutions, 2 drops in a minute and a half gives the best results. The air cylinder lubricators should be adjusted to feed regularly and the lubricator should be closed the minute the compressor is shut down.

Some engineers find out that the carbon deposit is easily cut away by kerosene oil and they throw kerosene oil into the inlet. Kerosene has a flashing point of 120 degrees F., and it is not difficult to understand what the cause of the explosion is under such circumstances.—*L. A. Christian, in Engineers' Review.*

An oiler looking like a turnbuckle and nearly as strong is used about the mines in the Rainy Lake district of Canada. It is made of a piece of ½-inch iron pipe, one end welded up solid and the other end closed down and a ½-inch nut welded in. The stopper which screws in has an eye by which the oiler may be hung up, or a string may be attached to it. The oiler, without the plug, is about 14 inches long and carries oil enough for one shift.

A NEW THAMES TUNNEL

When the Blackwall Tunnel under the Thames at London was opened ten years ago it was hailed as the greatest engineering work up to that time, but it is now surpassed by the Rotherhithe Tunnel under the same river. The main object in view was the linking up of two populous districts badly in need of direct communication, both the northern and the southern approaches being in close proximity to important main thoroughfares.

The Blackwall Tunnel is used by 1,250,000 foot passengers and 600,000 vehicles annually, which figures will be largely exceeded by the Rotherhithe Tunnel. The tunnel is circular, the lower portion forming a subway for water pipes, electric wires, etc. There will be room for a roadway 16 feet wide and footways 4 feet 8 inches on each side, and there will be a headway of 18 feet 6 inches.

There seems to huve been no novel or difficult engineering problems involved. The tunnel was driven by the now familiar shield system using compressed air, and the nature of the ground was such that there was no appreciable danger. Some thirty men were employed in the face of the shield, which was divided into sections 6 foot square. The progress has been as much as 12 feet per day, or 2 feet more than on the Blackwall Tunnel. Instead of the open strata which occur in the river bed at Blackwall there is a solid bed of clay. The tunnel has been driven under this bed of clay through what are known as the Woolwich and Reading beds. The tunnel is lined with cast-iron rings surrounded with lime grout. Some 20,000 tons of cement have been used and nearly 1,500,000 white glazed bricks.

The work has been done considerably within the contract time. The total time allowed, five and a half years, does not expire until two years from the present writing, but it is confidently announced that everything will be completed in one year. The Blackwall Tunnel occupied six years in construction. From London Bridge to Hammersmith there are fourteen bridges; below London Bridge there is one, the Tower Bridge. This is supplemented by the Blackwall Tunnel, the Greenwich Subway and the Woolwich Ferry. Even with the addition of the new Tunnel, East London will still make use of the ferry service run by the river steamboats between the piers below the bridge.

SUCTION REQUIRED FOR ENGINEERING PARTICULARS

A man will go into a pump manufactory and ask for a pump. A salesman will ask him: "What do you want to pump?" "Why, water, of course." "Is it hot or cold?" "Cold." "How much do you want an hour?" "I don't know." "Well, 10,000 gallons?" "Oh, not 1,000, it's just for my house." "Have you got a tank, and what is its size?" "Yes, I have a tank, and it is about so long, so deep, and so wide." "Well, that would hold about 2,000 gallons. Now our No. 4 pump will pump you 1,000 gallons per hour 60 feet high. Is your house as high as that?" "Oh, no; only about 30 feet." "You have a boiler, have you?" "Yes."

The man is sent his No. 4 pump, but he did not give the correct size of his tank and neglected to say his house was on a hill 600 feet away and 75 feet high. The pump does not answer and the man is mad.

Now abroad this would not occur. The man would be told: "You are not a professional man and therefore do not know what you want; and we do not wish to risk our reputation by guessing. Now you take our card and go and see Mr. M. or Mr. P., both good engineers, and they will see what you need and we shall be glad to fill the order for any pump they name."

You do not have to seek long for the cause of the condition existing in the United States, as it is the great desire here to make a sale that causes the trouble.—*W. D. Forbes, M. E. to Senior Class of Stevens Institute of Technology.*

THE WORLDS LARGEST IRON MINE

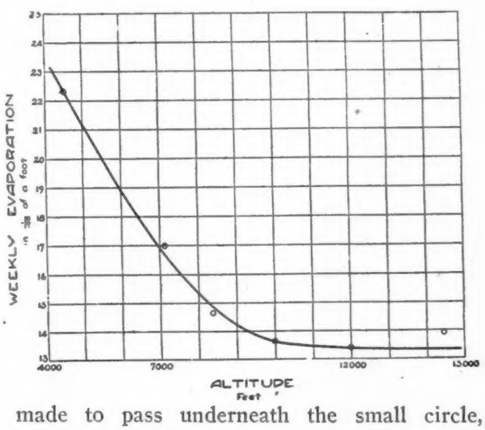
The United States Steel Corporation, through its subsidiary, the Oliver Iron Mining Company, is opening up what will be the largest mine of the kind in the world. With the aid of steam shovels and standard-gauge dump cars having a capacity of 7 to 9 tons, something like 20,000,000 cubic yards of dirt will be removed from the surface of the Canisteo iron ore deposit. This open pit, to be clover leaf in shape, covers 200 acres, and when the necessary development work has been done, will be from 160 to 200 feet deep. One of the principal features of this great enterprise will be the washing of the iron ores. Thousands of dollars have already been spent in the erection and operation of an experimental ore-washing plant.

INFLUENCE OF ALTITUDE ON EVAPORATION

During the summer of 1905, Mr. Frank Adams, of the Office of Experiment Stations, made a limited number of observations on the eastern slope of Mount Whitney, Cal., to determine the effect of altitude on the evaporation from a water surface. Temporary stations were established at the following points:

Station.	Elevation in feet.
Soldiers' Camp	4,515
Junction South Fork and Lone Pine Creek	7,125
Hunters' Camp	8,370
Lone Pine Lake	10,000
Mexican Camp	12,000
Summit Mount Whitney	14,502

The results of this investigation indicated a consistent and steady decrease in the evaporation of a 20-day period from the lower to the higher elevations. This is clearly shown by the accompanying diagram. The curve was



made to pass underneath the small circle, which marks the weekly evaporation on the summit of Mount Whitney, for the reason that the exposed position increased the evaporation. The intermediate stations, although selected with care, did not possess altogether uniform conditions as regards the movement of air and the character of the surrounding materials. While these doubtless influenced the results to some extent it is safe to conclude that altitude was the controlling factor.—*Engineering News.*

STRENGTH OF AIR PRESSURE TANKS*

The first air pressure tank, of which we have record, to be used as a source of water supply for an automatic sprinkler system was installed about twenty-four years ago.

The idea seemed to have prevailed with steel inspectors that any plate that would not pass inspection for firebox or boiler steel was good enough for tank steel, and was as a rule, sent out as such. Fortunately, we have had only a few cases of failure of the air pressure tank, resulting seriously.

A tank installed in connection with a sprinkler system in a building in Chicago, Ill., subsequently exploded. The following is a brief description of the tank and the conditions that led up to the disaster: Steel tank, 5 feet 6 inches in diameter by 24 feet long. Total capacity, about 4,300 gallons. Shell 5-16 inch thick. Heads, 5-16 inch thick. Dish of head, 8¼ inches. Longitudinal seams, triple riveted, with alternate rivets omitted on center row. Girth seams, single riveted. Rivets, ⅝ inch in diameter. Holes, 11-16 inch diameter, placed 1⅞ inches apart and ⅝ inch from edge of plates. The tank was originally allowed 75 pounds presssure, which was subsequently reduced to 40 pounds, under which pressure, it is said, the explosion took place.

An examination revealed the following conditions: The South head was torn nearly off, the break occurring at the end girth seam and along near the edge of head plate, running in an irregular line for about five-sixths of the circumference of the tank. Rivets were sheared off at irregular intervals. Rupture at edges showed no flaws, but plates had been materially weakened by rust, being only 3-16 inch thick at bottom of tank, where the rupture apparently started, and in several other places. Exterior of tank had never been painted, and was badly rusted out. Interior surfaces were badly pitted to a depth of nearly 1-16 inch, also covered with hard globular incrustations.

An explosion or bursting of a pressure tank might be attributed to any one of the following causes:

1. Defective design, resulting in general weakness of shell.

2. Poor construction, including choice of defective or improper material; faulty workmanship; failure to follow instructions and drawings.

3. Decay of the structure with time or in consequence of lack of care in its preservation, etc.

4. Mismanagement, giving rise to excessive pressure; failure to make frequent inspections and tests and thus keep watch on those defects which grow dangerous with time.

Defective design in the recently constructed tanks would not be so common as other causes.

The use of thin, laminated, or blistered sheets, carelessness in the attachment of inlet and outlet pipes, bad riveting, inferior quality of rivets, etc., could be considered as defective construction. Only the most careful as well as conscientious builders can be relied upon to avoid all such faults and to turn out tanks strong and safe as the design and specifications may permit.

The progressing decay by corrosion will develop weakness, and undoubtedly may be considered the most likely of all causes directly responsible for rupture or explosion. A tank designed and constructed of the best possible proportions and of the best materials, having at the start a factor of safety of six, may be assumed to be safe, but, with the beginning of its life, decay also begins, and the original margin of safety is continually being lessened. The result is an early reduction of this margin to that represented by the difference between the working pressure and that fixed as a maximum by the underwriters' rules or the inspectors' tests. Should this difference be sufficient to insure against accident resulting from further depreciation, in the interval between the inspectors' tests, explosion will not occur; should the margin be not sufficient, there is a possibility of explosive rupture occurring when least expected.

Rupture commences at the point where the resistance offered by the material is less than the strain to which it is subjected. The principal cause, as stated in the foregoing, affecting the strength at any one or more points is corrosion and decay. Not until this can be at least held in check will the danger of rupture be entirely eliminated. The inspection of the external conditions of a tank is, as a rule, taken care of, but, in order to ascertain the true conditions as to whether a tank is safe or not, a thorough internal inspection is absolutely necessary.

The city of Chicago requires safety valves

*From a Paper by Iry J. Owen, M. E., in Insurance Engineering.

to be installed on pipe line from pumps to tank, where a tank is found defective from corrosion, or where any apparent weakness has developed, reducing the working pressure from 75 pounds to 60 pounds, and in many instances to 45 pounds. In decreasing the pressure, the efficiency of the apparatus is considerably reduced.

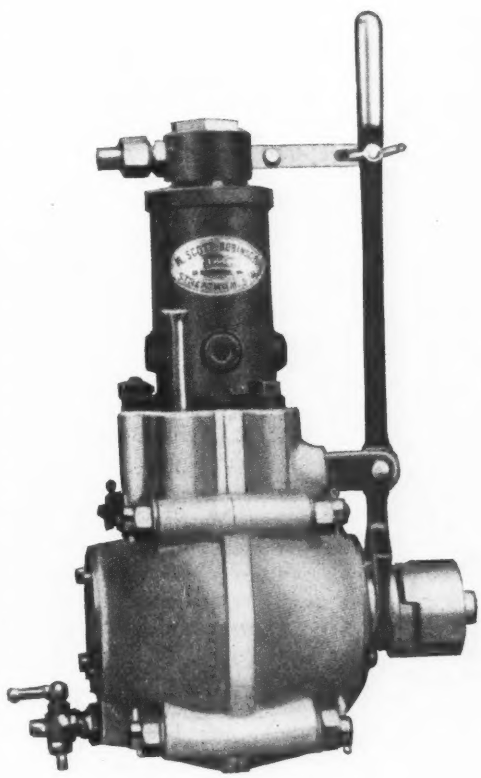
SOFT COAL BURNED WITHOUT SMOKE

The Commonwealth Edison Company is one of the largest coal consumers in Chicago. It has two enormous plants burning 1,600 tons of coal per day, these figures going up to 2,200 tons after November first. The Harrison street plant, Black Diamond assures us, has been a model of a non-smoke producer for years. It has demonstrated that even Springfield and other comparatively low grade western slacks can be burned absolutely without smoke. A practicable demonstration is given of the theory that, given plenty of head room between the fire and the boiler, smoke can be eliminated absolutely. The amount of head room required is still a matter of controversy, but that is a mere detail. Some of the experts declare that between 5 and 6 feet of head room is sufficient, while others, claiming to be equally expert in the prevention of smoke, declare that 9 feet is essential. The Commonwealth Edison Company has, in its demonstration, taken no chance and has given a good 14 feet between the point where the coal reaches the furnace and the point where the gases come into contact with the cool surface of the boiler tubes. This distance has been sufficient to permit all of the gases to reach a point of ignition and to burn themselves out.

But whatever the method pursued, the result is unquestionable, in that no smoke ever comes from the four stacks of the Harrison street plant of this company, even when firing is the heaviest. It is declared even that the fire can not be forced sufficiently to make the chimneys smoke. This very happy result was brought about by an invention of W. L. Abbott, the man in charge of the operation, who adjusted the fire grate and boiler in a way to produce the results desired. This same device has been promulgated by A. Bement, the mechanical engineer, and smoke prevention expert connected with the Peabody Coal Company.

THE ROBINSON AUXILIARY AUTOMOBILE AIR COMPRESSOR

This little compressor is to be fitted as most convenient on a car and may be driven either by a direct connecting clutch, as shown, to any rotating shaft, or by gears only in mesh when the machine is running, by belt or chain. It supplies air for inflating tires, blowing the "hooter," starting the engine, maintaining pressure on the oil tank, working lifting jacks, regulating oil supply to bearings, etc. This compressor weighs only $8\frac{1}{2}$ pounds; the cylinder is $1\frac{3}{4}$ in. by $2\frac{3}{4}$ in. stroke. The bar throws the clutch in or out as required. These compressors are also built in portable and stationary designs, with single and double cylinders for garages, etc. Mr. Scott Robinson, 24 Norfolk House Road, Streatham, S. W., London.



AUXILIARY AIR COMPRESSOR FOR AUTOMOBILES.

TEMPERATURES OF THE UPPER AIR

At the recent Congress of German Scientists at Dresden, Saxony, Prof. Hergesell told of his experiments with and records obtained by automatic apparatus sent up to great heights in unmanned balloons. The balloons were sent up in the month of July in different latitudes, and the results were quite surprising and in some respects quite the reverse of what might have been expected. It seemed to be demonstrated that at high altitudes the atmosphere is the coldest over the equator and the warmest over the poles. Balloons which went up to a height of 11 to 12½ miles in the tropics were found to have registered about 148 degrees below zero, Fahrenheit, while in the latitude of central Europe the temperature was only —76 to —85 degrees at the heights indicated. The temperatures do not continually fall with the ascent, the greatest cold being reached at heights of from 6 to 6¾ miles, varying somewhat in different parts of the world. Prof. Hergesell concludes that the atmospheric conditions which affect our weather do not extend higher than seven miles.

COMPRESSED AIR FOR STARTING GAS ENGINES

The following information is taken from the catalog of The Bruce-Merriam-Abbot Company, Cleveland: A gas engine will not start by simply turning on the gas. It must in some way be given several revolutions in order to draw in the proper charge and start the explosions. On cheap engines and in smaller sizes, it is simply a matter of "cranking." Some engine builders use a hand air pump to fill the cylinder for the first time with an explosive mixture and then ignite this with a match. Another method is to prime the cylinder by sucking a little gasoline into the cylinder through the pet cock during a forward stroke of the piston and then backing it up hard against the compression, while some one else trips off the ignition. These methods are, however, partly accountable for the bad name which gas engines have often received, and it is high time that a reliable method were universally adopted.

The method which we use on all engines larger than 12 horsepower is to install an air compressor, which is driven by the engine, and which fills two tanks with air at 200 pounds pressure. To apply this air in starting the engine, we use a device which so shifts the cams operating the valves on the engine, as to enable the use of one of the cylinders as a single acting air engine or steam engine. In this way the starting of the engine becomes as positive and as simple as the starting of a steam plant. The other great advantage of the twin cylinder engine in starting, is self evident from the fact that while one cylinder is acting as an air engine, the other cylinder begins at once to operate as a gas engine. The air valve is then shut off and the cam so shifted as to cause both cylinders to operate as a gas engine. We supply two tanks, either one of which will start the engine half a dozen times. In very large plants where it is desired, a small engine may be used to drive the air compressor, in which case only one tank would be used. Also, where two engines are used to drive dynamos, we install a small motor to operate the air compressor, in which case the air compressor can be operated while either engine is running.

CATHEDRALS AS RECORDS OF ATMOSPHERIC CONTAMINATION

In a report by the Dean of York Minister concerning the recently completed restoration of the west front occurs the following: "It will be well, therefore, if for some time to come the condition of the fabric is regarded not only for ecclesiastical and archæological reasons, but as a token to the citizens generally of what is really the prevailing condition of the atmosphere which they are compelled to breathe and in which they live." This same west front was restored a hundred years ago and other buildings built of the same stone but situated outside of York have suffered no degradation from atmospheric causes, and the Dean argues, citing Faraday, Sir Frederick Treves, Sir Oliver Lodge, Sir William Richmond and others, that the cause of the deterioration of the Minister's front is to be found in "the number of smoke-emitting chimneys throughout York," and that smoke-laden air is as injurious to human beings as to stone buildings. And so this zealous British ecclesiastic argues that as a means of determining the hygienic quality of the circumambient atmosphere, the cathedrals of Great Britain must be kept in artistic and architectural repair.

COMPRESSED AIR

AND EVERYTHING PNEUMATIC

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CONTENTS.

THE ELECTRIC AIR DRILL

The Electric Air Drill, the principal features of which are brought to our notice in the paper of Mr. W. L. Saunders in our present issue, seems to be an invention, the applications and consequences, and also the economies and advantages, of which are not yet all revealed. While it completely enables the electric current to be advantageously applied to the driving of the rock drill and its allied devices, so that in most cases the last obstacle to the exclusive employment of electric transmission in mine, tunnel and quarry work, and to large engineering enterprises involving much rock cutting, is removed, it is of not less interest when its pneumatic features are looked into. In fact, the invention after all is more in the pneumatic than in the electric details of its application. The most curious and satisfactory of the results accomplished is in the elimination of the familiar and hitherto unavoidable loss of power which has occurred in the compression of air and in the application of the pressure to mechanical operations. This loss has resulted heretofore from the separating of the apparatus and operation of compression, involving the expenditure of power, from those of the reëxpansion or release of the pressure by which power was realized and work accomplished. In the simplest arrangement hitherto there has been a compressor with all the necessary inlet and discharge valves, then a receiver and a pipe line and at the other end cylinders with other valves and valve operating devices and pistons which carried or operated the ports which did the work. James Watt brought economy of operation to the steam engine by complicating the apparatus employed, adding the condenser and the air pump to the cylinder, and in the development of most of our inventions the tendency has been first to improve them by adding one contraption to another, simplification coming laboriously and slowly later if at all. The Electric Air Drill makes the jump all at once. Receiver and pipe line are thrown away and in operation the compressing cylinder and the reexpanding or working cylinder are made one by the single body of air which at all times fills them both. The heating and increase of volume of the air under compression and the additional uncompensated power entailed for the compression heretofore unavoidable on the one hand, and the loss of power through the

cooling and shrinking of the air while doing the work on the other, are both transformed to advantage and the losses are eliminated. There are various other features of the Electric Air Drill inviting investigation before a full understanding and an adequate appreciation of it are attained.

"IT GIVES BACK ALL THE CHANGE"

We probably quite generally appreciate the happy catch phrases which become so familiar and which so jauntily carry the ideas which make things go in the world of advertising. Some of them have been carefully and laboriously molded for their special missions; a common belief, however, is that the best of them have had an apparently fortuitous origin. Their apt suggestiveness or their facility of catching and holding have often been realized afterwards rather than at the instant of their first putting forth.

The better phrase really, and the one ultimately the most telling and successful, is that which suggests some actual and special characteristic or property pertaining to the individual thing spoken of. "It gives back all the the change," as above, carries a positive statement concerning a certain pumping system, and at the same time implies, or practically asserts, that other systems do not give back all the change, or do absorb, dissipate or in some way take more than the power actually requisite for the work and which ought to be expended for it. The phrase thus truthfully and very intelligibly carries both high commendation and severe condemnation. How, if preventable, is mechanical dishonesty any more justifiable than financial dishonesty?

"It gives back all the change" is used as specially applicable to the return-air system of pumping water, and the analogy suggested is well sustained throughout. The operation of elevating water by the expenditure of power, the power being applied either directly or intermediately, is quite similar to the purchasing of goods in the market by the expenditure of money. There is a price which is just and right for anything man may buy, and, similarly, there is also and always a certain expenditure of power which would be exactly right for raising any quantity of water to any given height.

We do not have to go far to find the systems of water raising which do not give back all, or indeed any, of the change, for such systems are most familiar. We speak here particularly of the devices which use compressed air as the medium, the air compressed and used representing the power cost of its compression, just as silver or gold represent the labor cost of their production. In the case of the direct application pump we have first a tankful of water which is to be expelled and driven up through a pipe to the point of delivery. Compressed air is accordingly admitted at sufficient pressure to expel the water, and when the water is thus expelled the tank is full of the air at its full pressure.

We may now imagine the tank to be an engine cylinder with a moving piston, which at the moment is somewhere in the first half of its stroke and at the precise point where cut-off occurs. The end of the cylinder up to the piston is filled with full-pressure air, and this volume of air is the total air expenditure for that engine stroke. In the case of the water tank this volume of air has done all the work that it will be permitted to do, and it is at once discharged. In the case of the engine the equal volume of air, instead of being discharged, continues to do work by driving the piston to the end of its stroke, all the work so done in addition being the change which the direct displacement pump failed to utilize or to return any equivalent for. In the return-air pump the work of expelling the water from the tank is quite similar to the work of the direct displacement pump, but after that the returning of the change occurs, the air, instead of being discharged, being turned into the intake pipe of the compressor, and in its expansion it helps to drive the compressor or to repay the cost of the original compression. This thus told is a simple enough device, but it represents mechanical honesty and profit.—*Cassier's Magazine.*

POWER IN MANUFACTURES

The Bureau of the Census has just issued Bulletin 88, which is a report on the power employed in manufactures. The total power employed in manufactures, in 1904, according to this report, was 14,641,544 horsepower. To this amount steam engines contributed 10,828,-111 horsepower, or 73.9 per cent.; water wheels, 1,647,969 horsepower, or 11.3 per cent.; electric power, owned or rented, 1,592,483 horsepower, or 10.9 per cent.; gas or gasoline

engines, 289,514 horsepower, or 2 per cent.; and other kinds of power, 283,467 horsepower, or 1.9 per cent.

When compared with the figures reported at the census of 1900, those of 1905 show that in five years the total horsepower increased more than 40 per cent. The power of gas and gasoline engines increased 114.9 per cent. The largest absolute increase however, was reported for steam engines, the horsepower of which increased 2,687,578, or 33 per cent. The power of water wheels increased only 13.3 per cent.

The Middle States ranked first, reporting 5,000,367 horsepower. The Central States, 4,077,298 horsepower; Southern States, 2,386,330; New England States, 2,254,264; the Pacific States, 474,397, and the Western States, 445,937. Perhaps the most striking fact is that the Southern States reported more power than New England. The development in the Southern States has been in the utilization of steam power. In the South 87.4 per cent. of the power was derived from steam and 6.2 per cent. from water, but in New England 59.3 per cent. was from steam and 29.2 from water.

The effect of a heavy industry on the utilization of steam power is illustrated by the fact that Pennsylvania, the principal center of the iron and steel industry, reported 2,088,773 steam horsepower, or almost 20 per cent. of the total for the whole country. Ohio reported 1,028,665, so that these two states have nearly 30 per cent. of the entire steam power employed in manufactures, a fact which results largely from the use of steam power in the metal industries. New York ranked third, with 850,497 steam horsepower; Massachusetts fourth, with 690,467, and Illinois fifth, with 651,578.

The largest amount of water power used in manufactures at the census of 1905 was reported by New York. The capacity in that State increased from 335,411 horsepower in 1900 to 446,134 horsepower in 1905, giving that State 27.1 per cent. of the total for the whole country. The continued leadership of New York in the use of water power is due largely to the utilization of this kind of power in the paper and wood pulp industry. Of the total water power reported by New York at the census of 1905, paper and wood pulp manufactures used 73 per cent.

The next largest utilization of water power in manufactures was reported by the State of Maine, with 203,904 horsepower, followed closely by Massachusetts, with 183,427 horsepower. Wisconsin was fourth, with 112,665 horsepower. In Wisconsin, as in Maine and New York, the paper and wood pulp industry is the largest consumer of water power, while in Massachusetts the cotton and wool industries are the largest.

Besides the power derived from steam, water, electricity, gas and gasoline, 92,154 horsepower was reported at the census of 1905 as owned by manufacturing establishments. A large part of the power included in this class is pneumatic, although probably some hot-air engines also are included. The general introduction of pneumatic tools has resulted in the installation in various shops and factories of large pneumatic plants to supply the compressed air to drive these tools.

CORRESPONDENCE

The Editor of COMPRESSED AIR recently received a letter which called for a reply but the signature to which was absolutely undecipherable. The text of the letter was perfectly legible, as was also the address of the writer other than the signature, so that in replying we began our letter, "Dear Mr. What's-Your-Name," and then pasted the signature of the writer upon the envelope. In this treatment of the matter certainly no discourtesy was intended.

Editor Compressed Air:

Unless Mr. John J. Smith can establish an earlier date than 1890, as given in your August issue, for the publication of Johnson's and Church's formulæ for the flow of air in long pipes, the credit of being first to construct a rational formula belongs to Prof. Unwin, for he published his formulæ and gave their derivation in the proceedings of the Institute of Civil Engineers of London for 1875—6 Vol. XLIII.

Since noticing Mr. Smith's communication I have not had an opportunity to look up the formulæ he mentions, so will not attempt to criticise them at this time.

B. C. BATCHELLER.

Editor Compressed Air:

In your October number under the head of "Vacuum Makes a Record" is an item that I don't understand. The unsophisticated are led to believe that you can get a vacuum beyond 15 pounds or 30 inches. I would like to have

you explain why you take up valuable space in your paper and the time of your readers with such rubbish. GEO. J. KINDEL.

DIFFERENT VACUUMS

Editor Compressed Air:

The little piece in your October issue about the 400-pound vacuum probably produced a smile on the face of more than one reader, as I suppose was intended, but it occurs to me that under certain conditions a vacuum of 400 pounds might not be such an absurdity after all. It's a curious thing about vacuum and the way we measure and record it. I know well enough about the dictionary definition of vacuum. It's an entire absence of air or anything else. The actual vacuums we know about are only partial differences or deficiencies as compared with fullness or excess of pressure elsewhere. Any partial vacuum, as our gages indicate it, may be reported as more or less without the slightest change of the vacuum itself, but entirely on account of changes of the pressure outside the gage. We ordinarily state a condition of vacuum by its comparison with ordinary atmospheric pressure, but we know that this pressure is constantly changing and varies widely with change of altitude. Comparing external and internal pressures in working with compressed air there are cases where the full atmosphere may itself be considered to be a vacuum.

Perhaps you question this; let's see about it. In the first pumping engines steam filled the cylinder at atmospheric pressure, and then when this steam was condensed, and left only a thin, weak vapor in its place, the atmospheric pressure on the other side of the piston did the work. The air would have been powerless except for the vacuum.

Several years ago when they were sinking the caisson for the central pier of Washington Bridge over the Harlem River, New York City, and had got down nearly as deep as was necessary, an air pressure of 30 pounds being maintained in the caisson to exclude the water, there was encountered some rock which it was necessary to remove. A rock drill was sent down and put to work, and with the aid of some light charges of dynamite after the drilling the rock was soon removed. The curious thing about it was that no compressed air was piped to the drill to drive it. A hose conducted the exhaust of the drill up out of the caisson to the open air, and then upon opening the drill throttle and admitting the air to the drill at the caisson pressure of, say, 30 pounds, this pressure was sufficient to drive the drill piston and do the work required. Here, as in the case of the primitive pumping engine, the air pressure only became effective when the vacuum was secured to weakly oppose it, the vacuum in this case being the atmospheric air at normal pressure.

When this drill was thus being operated by the caisson pressure the vacuum against which it was working might have been measured by an ordinary vacuum gage in the usual way, only that the range of the gage would not have been sufficient for the vacuum to be indicated. A **U** mercury gage of the familiar type, if long enough, would have done the business perfectly. If one leg of the gage was connected by a tube to the atmosphere and the other end left open then the difference in the heights of the mercury in the two legs would have been about 60 inches, and who wants to say that would not have been 60 inches of vacuum? This would have been the relative or operative vacuum, while the absolute vacuum would of course have been 60+30, or about 90 inches, and this would have been shown if a vertical single-tube mercury vacuum gage, or barometer, without piping to anything, had been used in the caisson.

We have still another and a different illustration of vacuum effect in subaqueous rock work around New York City. In the driving of the tunnels under the North and the East Rivers it was found necessary to maintain a constant pressure in the tunnels sufficient to exclude the water, this pressure depending upon the relative depth of the work below the water surface, and it may here be assumed to have been 25 pounds above that of the normal atmosphere. Rock drills were used quite extensively in these tunnels, but they exhausted into the tunnel atmosphere, or against the pressure, 25 pounds gage, in which the men were working.

As a consequence of this condition two distinct air pressures were maintained in the tunnels during the entire progress of the work, and two separate systems of air compressors and of piping were installed. The low pressure compressors maintained the 25 pounds in which the men worked, the high pressure compressors supplied the air for driving the drills, and as the exhaust of the drills was

against an abnormal additional resistance of 25 pounds, the high pressure air to drive them was required to be 25 pounds above that usually employed for ordinary outdoor work.

Allowing 80 pounds, gage, for ordinary drill running, this in the tunnels became 80+25=105 lbs. to do the work with equal effect. In this tunnel work, therefore, there were four distinct levels of pressure in sight, either of which might have been considered a vacuum relatively to that above it, and could have been shown to be such by a vacuum gage of sufficient range and properly connected. The highest, or drill-driving, pressure was 80+25+15, the tunnel working pressure was 25+15, the atmosphere was 15 and then there was the always possible absolute vacuum, 0.

Vacuum—not absolute—is as necessary as pressure to make things go. If a loaded cannon was sunk deep enough in the ocean and fired by wire I don't suppose it would have any effect on account of the absence of vacuum. At a depth of six miles the gases generated would have to have a pressure of over 6½ tons to the square inch merely to overcome the pressure in the muzzle. The actual gas pressures when a big gun is fired are, however, greater than this, so that a much deeper puddle would have to be found to make this true.

TECUMSEH SWIFT.

The regular monthly meeting of the American Society of Mechanical Engineers will be on Tuesday evening, November 12, in the Engineering Societies Building, 29 West 39th street, New York. Mr. Charles R. Pratt will read a paper on the Gearless Traction Electric Elevator as installed in the two highest buildings in New York. The paper will be discussed by engineers and architects from New York, Philadelphia and Chicago. Members of all professions are invited.

QUESTIONS AND ANSWERS

S. A. D., Mount Carbon, Colo. *Q.*: A certain coal mine makes 500 gallons of water per minute, the present head is 500 feet and we must figure on a continuous pumping service; what pumping arrangements, using compressed air, will give the most economical and satisfactory service?

A.: There are two quite different methods which would be suitable. One is the Dense-Air system, using compressed air at a high pressure to drive an ordinary direct-acting steam pump, the exhaust being piped back to the compressor at a pressure considerably above atmosphere, by which means "R"—the ratio of compression and expansion—is greatly reduced and a considerable reduction in the thermodynamic losses is effected. See article upon this subject in COMPRESSED AIR for October.

The efficiency of this system depends largely upon the height and the range of pressures used. The use of excessive pressures, however, involves special piping, special pumps and compressors, which thus determine the practical limit. With a discharge pressure of 150 pounds and a return pressure of 85 pounds, both at the compressor, the efficiency between the indicated horsepower in the steam cylinder of the compressor and the indicated horsepower in the pump air cylinder would be about 45 per cent. The ultimate efficiency computed from the water actually delivered would be still further reduced by pipe friction and the mechanical friction throughout, so that not more than 30 per cent. could be expected to be realized.

The other method of pumping spoken of as applicable to the above case is the Return-Air system. The water to be lifted is enclosed in a tank and is expelled and driven up a pipe to the height required by direct-air pressure. After this water has been expelled the air is not discharged into the atmosphere but is returned to the intake of the compressor, its pressure acting upon the rear of the piston and assisting in the work of compression, its expansive force being thus utilized. Usually two tanks are employed, the operations of filling and of expelling alternating in each. By this employment of the return air a large portion of its energy is saved, the principal losses still remaining being the thermodynamic losses and those due to the clearance spaces of the pipes.

The thermodynamic losses can be reduced by cutting down the value of "R," and for this it is proposed to compound the simple return-air system as outlined above, thus reducing "R" to the square root of what it would be between a sufficient pressure for the whole lift and atmospheric intake. This compounding would necessitate the use of two air cylinders, which could be arranged tandem rather than on opposite sides of a duplex machine, on account of the great difference in the two horsepowers.

The clearance space introduced by the air pipes involves a loss which bears a certain proportion to the percentage of this clearance as compared with the volumes of the tanks. The longer and larger the pipes the larger will the tanks have to be to realize a given efficiency. An efficiency as high as 40 to 45 per cent. we are assured could be guaranteed.

In the compound system the water from the first pair of tanks would be delivered to the second pair under a certain pressure, the latter delivering against the final pressure. As a second-stage tank would not be ready to receive water at the beginning of a cycle, provision would have to be made for an intermediate storage of either the water or the air, and this could be done either by providing a sump part way up the shaft, where part of the water could ascend temporarily, returning when the second-stage tank was ready to receive it, or the delivery of the water from the first-stage tank could be temporarily deferred until the second-stage tank was ready to receive it, the charge of air for expelling the water being meanwhile pumped by the compressor into a receiver so large that it could receive this charge without a rise of pressure of more than 10 or 15 pounds. The work done on the air in raising it to this higher pressure would not be entirely thrown away as the water would be delivered to the second-stage tank at this higher pressure, and the pressure on the returning air of the second stage acting against the compressor piston would be maintained for a longer period and at a pressure in excess of the normal filling pressure of the second stage, thus giving up to the second-stage cylinder a large part of the apparently unnecessary work done by the first-stage cylinder. M. W. SHERWOOD.

W. M. S., Batson, Texas. *Q.*: I wish to raise a valve off its seat, with a wound soft iron horse-shoe magnet, against a pressure of 120 pounds per square inch. The orifice is one-quarter of an inch. Will you kindly give me the dimensions of a magnet which will be sufficiently strong to do this work? As I will want to use several hundred of them from one general station, how many of them can be run per horsepower?

A.: As this is a question for an electrical expert we will not attempt to answer it. Probably no one could be found to reply who would not ask several questions. To begin with, what is the required valve movement and total weight of the valve and stem or other part to be moved? Is the valve in air or in water and would the magnet be located inside or outside the valve chamber? Would the face of the magnet be in actual contact with the valve or stem and move with it in opening the valve or would the magnet be located at a distance equal to the valve lift and the valve be expected to jump to the magnet every time it was lifted? Why use a horse-shoe magnet?

These queries are here intended as hints for other inquirers. Please give particulars and if necessary sketches also, so that a reply may be expected to fit the case.

TRADE PUBLICATIONS

Applications of Thermit in Foundry Practice and Butt Welding by the Thermit Process. — Goldschmidt Thermit Company, New York. Each 12 pages, 6x9 inches; illustrated.

The United Service & Tube Company, Boston, issue a pamphlet describing their system of foot power pneumatic tubes for store and office transmission. No power is required except the pressure of the foot.

Extra Heavy Valves.—12 pages, 5¼x7¾ inches, illustrated. Describes and gives dimensions of a full line of globe, check and other valves for pressures of 300 pounds. Made by Jenkins Bros., 71 John Street, New York.

Efficient Bearings.—Franklin Filter Co., St. Louis, Mo.—16 pages, 6x9 inches, illustrated. Describes the Franklin Oil Filter and explains numerous applications of it, including a complete system of automatic lubrication for large plants.

Morris Metallic Packing.—Catalog No. 110 of the H. W. Johns-Manville Co., New York. 16 pages, 4½x7 inches, illustrated. Shows the different styles and applications of this make of metallic packing with directions for dimensioning and applying.

Modern Welded Pipe.—National Tube Company, Pittsburg, Pa.—32 pages, 6x9 inches, large number of halftones. This attractive pamphlet gives an outline of the progressive operations in the manufacture of steel tubing from the ore to the finished product.

The United Service & Tube Company, Boston, have entered the field for the manufacture and installation of Pneumatic Tube Service for carrying cash, messages, packages, etc.

They have issued a little circular giving the records of the four principal officers.

The Belt Book.—A Magazine for the Users of Belting, September, 1907. Published by Chas. A. Schieren & Co., New York City. 20 pages, 10x7½ inches, illustrated. Contains a variety of interesting matter concerning The Tanners of Nieuw Amsterdam, leather and belting.

The Expanded Metal System of Steel Concrete Construction, Expanded Metal Engineering Co., 225 Fifth Avenue, New York. 176 pages, 5x8 inches. Numerous halftones with tables and general practical information concerning this valuable element in modern construction.

The Independent Pneumatic Tool Company, Chicago, New York.—Catalog No. 8. 80 pages, 6x9 inches; more than 100 half-tones. Describes the entire line of *Thor* Pneumatic Tools and illustrates their various applications. Tables of dimensions and capacities of the several sizes make the information complete.

The Hanna Engineering Works, 820 Elston Avenue, Chicago, have issued a circular illustrating their line of Hanna Riveters and describing the peculiar mechanical movement employed whereby a uniform maximum pressure is exerted throughout the last half of the piston travel, thus giving hydraulic results with a pneumatic apparatus.

Can You Use a Small Air Compressor? Ingersoll-Rand Co., 11 Broadway, New York; 20 pages, 3¼x5¾ inches, numerous half-tones. This handy leaflet tells about the Imperial, Type Eleven, compressors built by this company. These machines are vertical, belt or motor driven, having air cylinders either duplex or compound with normal free air capacities ranging from 8 to 500 cubic feet per minute and for any pressure up to 100 pounds. The adaptability and popularity of these machines is attested by the list given of 120 different lines of service in which they are employed.

SAND BLASTING BEFORE PAINTING

At the recent annual meeting of the Master Car and Locomotive Painters' Association an elaborate report was presented upon the Painting of Steel Passenger Cars. The following concerning the cleaning of the surfaces before the painting is of interest to our readers:

Before any protective coatings are applied, all oil, grease, dirt, scale and rust should be entirely removed, and a priming coat applied before additional rust forms on the surface. This may be accomplished in several ways, the treatment being varied according to the condition of the metal, and the conditions under which the work is done. The oil and grease may be removed by benzine or turpentine and wiping with rags or waste. Scale and rust can be most thoroughly removed by the sand blast, or by dipping the parts in a sulphuric acid bath, and rinsing with water. Conditions may be such that certain parts cannot well be cleaned by the best methods and in such cases scrapers and wire brushes may be used to advantage. For cleaning all exposed parts, however, we strongly urge the use of the sand blast; also for interior parts that are to be coated.

NOTES

During July 19.38 miles of holes were drilled on the Panama Canal work, as follows: Steam and air rock drills, 55,290 feet; well and mechanical churn drills, 34,246 feet; hand drilling, 12,789 feet.

In France the depth of drill holes for blasting is restricted to 1½ meters, or about 5 feet. The miner is forbidden to touch a hole after it has once been fired and when a shot is missed, the hole must be drilled over.

An investigation of manhole explosions at Aberdeen, Scotland, disclosed the fact that coal gas leaking from street mains may become odorless by filterng through a moderately thick layer of earth without losing its explosive condition.

In consequence of the official inquiry into the causes of the Courrieres catastrophe, the French minister of public works has decided that mines must be provided with breathing appliances, ready for immediate use, and permitting their wearers to remain at least an hour in an inrespirable atmosphere.

In the upper right hand corner of meters used for measuring natural gas is a little dial by which it can be determined if there is a leak in the household plumbing. When no gas

is being used for any purpose the hand upon this dial should be still, and any movement of it is sure evidence of leakage in pipe or fittings.

Russian units of weights and measures are complex. For instance, 1 pood is equivalent to 36.1128 pounds avoirdupois, or 526.645 ounces troy, or 16.38 kilograms. One funt equals 0.9028 pound avoirdupois, or 13.166 ounces troy, or 409.512 grams. One sajene equals 2.1336 meters. One archine equals 0.7112 meter.

A gasworks on the shore of Lake Constance, Switzerland, supplying the town of St. Gall, six miles away, is in the happy position of being able to sell and deliver a greater volume of gas than it makes. The factory happens to be situated 820 feet lower than the holder and the place where the gas is consumed, and as the gas rises it of course expands before it is delivered.

They are certainly making the dirt fly in the Canal Zone. The following is the August record for the steam shovels: Culebra division, 786,866 cubic yards; Gatun lock site and spillway, 105,223 cubic yards; Mindi, 15,527 cubic yards; La Baca, 6,784 cubic yards; Chargres division, 2,280 cubic yards. The dredges at the Colon terminal excavated 189,170 cubic yards and at the Pacific terminal 168,284 cubic yards. Here is a total for one month of 1,274,404 cubic yards.

The French Government has approved the system of submarine signalling, and has ordered submarine signal bells, actuated by pneumatic power, to be placed at the ends of the piers at Calais, Boulogne and Havre, and a submarine signal buoy to be placed for trial off Havre. A submarine signal bell has been fitted to the Sandette lightship, off Dunkirk, for some time. When these bells are working there will be practically a continuous system of submarine signals from Havre to the Elbe.

Considerable progress is being made in Europe in turbine air compressors, Professor Rateau having constructed machines which compress air to six and even seven atmospheres, and fifteen compressors varying from 800 to 2,000 horse-power are now on order. The efficiency of these machines is said to be of the same order as that of piston compressors, and, contrary to what might be expected, the machines possess great flexibility in output. The machines are compounded, compressors with a single wheel being only suitable for an outlet pressure of about one-half atmosphere.

In California a contract has been let for the building of a rifled oil pipe line 256 miles long. Spiral indentations in the interior of the pipe, 8 inches in diameter, cause the liquid column to rotate as it flows, and a small percentage of water being added to the oil, this, being heavier, is carried to the periphery and forms a lubricant, greatly reducing the friction and allowing the core of oil to glide easily. There will be twenty-three pumping stations on the line and it is estimated that 23,000 barrels of fuel oil can be delivered every twenty-four hours, which would require a constant flow of two and one-half miles an hour.

While a compressor and the attached piping system were being tested recently at the new plant of the Woodruff Ice Company at Peoria, Ill., the discharge chest on the left-hand cylinder burst and badly shattered the ⅝-inch cast-iron water-jacket surrounding the cylinder. The erecting and the operating engineers were both somewhat injured. The gage at the time of the accident showed only 240 pounds, whereas the machine had been tested on the day previous to 300 pounds, and in the shop to 500 pounds. It is, therefore, surmised that the fracture was due to an explosion of oil vapor due to the heat generated by compression, there being no circulation in the water-jacket at the time.—*Power.*

Direct-acting steam pumps, both single and duplex, are largely used through the mining fields. They are extravagant in the consumption of fuel even under the best of conditions, and are liable to great additional losses from the use of leaky steam valves and pistons. Careful tests under favorable conditions, and the data obtained from actual practice show the following consumption of steam or fuel per horse-power per hour: Triplex power pumps require 1½ to 5 pounds coal per horse-power per hour; small steam pumps, 25 pounds; large steam pumps, compounded, 13 pounds; pulsometer pumps, 60 to 70 pounds; injectors and inspirators, 100 pounds per horse-power per hour.

It is a peculiar function of a fan blower that instead of always delivering a fixed volume of air, regardless of requirements, it automatically increases the volume as the resistances are decreased. On the other hand, if the blower be in operation with a fairly free outlet, in excess of its capacity area, and that free area be decreased, the pressure produced will immediately rise, thus tending at once to overcome the increased resistance. Therefore, if a certain maximum pressure is known to be required, the fan may be so speeded as to give this at such times as the conditions demand; while at other times, when less pressure or volume of air is required proper manipulation of the blast gate will economize power.

The dimensions and powers of gas engines would seem to be approaching the limit in the United States as well as in Europe. Cylinders 44-inch diameter and 54-inch stroke are under construction by the Allis-Chambers Co. for the power houses of the Indiana Steel Co., at Gary, Ind. The engines are four cycle, twin-tandem, direct-acting, designed to give 4,000 horsepower on blast furnace gas of 80 to 85 b. t. u. and up to 5,000 horsepower on richer gases. They are intended for direct connection to alternating-current generators. The crank pins are 20 inches in diameter, the shaft 30 inches and the fly-wheel 23 feet. The fly-wheel weighs approximately 200,000 pounds and the entire engine, roughly, 1,500,000 pounds.

In drilling for a small rock cut on Manhattan Island, New York, the work was done by hand. Two strikers and a holder average 15 feet per ten-hour day. Each hole was 7½ feet deep, the starting bit being 1⅞ inches and the finishing bit 1¼ inches. The rock was a tough mica-schist. Each man averaged 5 feet of hole per day, which is equivalent to 40 cents per lineal foot when wages are $2 a day. The holes were spaced very close together, averaging only 2½ feet apart. Hence it required 4.3 lineal feet of drill hole per cubic yard excavated, which, at 40 cents per lineal foot, made the cost $1.72 per cubic yard for drilling alone. The job was being done on a percentage basis, which may account, in part, for the fact that the contractor permitted such close spacing of the drill holes. As a matter of fact, small as the job was, it would have paid handsomely to have installed a steam drilling plant. The cost given does not include the cost of sharpening the steel or carrying it to and from the blacksmith shop.—*Engineering-Contracting.*

It is an encouraging sign of the times that even coal mines are beginning to appreciate the value of coal and to practice the familiar economies even at the mines. Not only is the coal that is saved worth the saving but the initial cost of boiler plant and the reduction in the labor item, in connection with the greater reliability and the reduced cost of maintenance constitute a large aggregate reduction of operating expense. The power plant of the Berwind-White Coal Company at its No. 40 mine seems to leave little to be suggested. The mine is operated entirely by compressed air and electricity, and the power plant comprises two Ingersoll-Rand Corliss air compressors and three generator units direct connected to Cooper-Corliss cross compound engines. The steam cylinders of the compressors are 20 and 40 and the air cylinders 34¼ and 22¼ inch diameter by 36 inch stroke. A gravity oiling system serves the entire plant. A battery of Stirling boilers maintains a steam pressure of 150 pounds and a barometric condenser gives a constant vacuum of 24¼ inches.

Power transmission from waterfalls has been rapidly and remarkably extended in the Southern States: The Catawba is a particularly interesting example. This stream, having its origin near the foothills of the Blue Ridge Mountains, is hardly to be termed a large river, yet it has been "harnessed" to an extent that is significant of the results that can be accomplished in this direction. Beginning near the headwaters of the river, there are the Rodhiss cotton mill, 1,500 horsepower; the Long Island mill, 300 horsepower; Monbo mills, 150; Mountain Island, 1,000, and Tuckaseegee, 250 horsepower. The Catawba power plant develops 10,000 horsepower, and the Great Falls plant 30,000 horsepower. On the south fork of the river, over 3,000 horsepower is utilized entirely for cotton-mill operation. A few miles below the Great Falls plant work is in progress on the Rocky Creek plant, with 20,000 horsepower, and above Great Falls a 15,000 plant is to be erected. The plants complete, underway, or yet to be developed, require about $250,000 a month outlay. The latest estimate is that there will be 140,000 horsepower in use alone in a radius of 70 miles from Charlotte, N. C.

Electrical air filtration is suggested by an experimenter, who has discovered that a body positively electrified to 100 volts or over will, if placed in a sooty atmosphere, become covered with soot in a day, while a negatively charged body remains comparatively clean. In an application of this discovery to the fan intake of a ventilating system, a sheet of wire gauze was inserted in the intake flue, and electrified by connection to the positive of a 250-volt main. The gauze is reported to have extracted large quantities of soot from the air.—*The Engineer* (London).

LATEST U. S. PATENTS

Full specifications and drawings of any patent may be obtained by sending five cents (not stamps) to the Commissioner of Patents, Washington, Pa.

September 3.

864,810. HUMIDIFYING APPARATUS. John Taylor, Manchester, England.

864,918. AUTOMATIC AIR-PUMP. Edward J. Rohrbacher, Blaine, Wash.

865,014. DISCHARGE-VALVE FOR FLUID-COMPRESSORS. Niels A. Christensen, Milwaukee, Wis.

865,015. COMPRESSOR. Niels A. Christensen, Milwaukee, Wis.

865,130. APPARATUS FOR RAISING SUNKEN VESSELS. Ferdando Staud y Ximenez, Chicago, Ill.

865,210. AIR-BRAKE APPARATUS. William T. Robinson, James W. Neighbours, and Wilbourn O. Pierce, Pulaski, Va.

865,218. AIR-SUPPLYING MEANS FOR EXPLOSIVE-ENGINES. August Wagener, Berlin, Germany.

865,333. PROCESS OF SMELTING ORE AND CONVERTING MATTE. Arthur M. Day, Bingham Canyon, Utah.

The process of smelting ore and converting matte, consisting in forcing air into the charge and injecting powdered silica or silicious material in a fluent form through one or more twyers with an air blast separate and distinct from the air supply to either twyers, substantially as described.

865,337. PNEUMATIC TOOL. Frederick S. Graham, Philadelphia, Pa.

September 10.

865,388. CONTROL OF AN ELECTRICALLY-DRIVEN AIR-COMPRESSOR. Ebenezer Hill, Norwalk, Conn.

865,389. CONTROL OF ELECTRICALLY-DRIVEN AIR-COMPRESSOR. Ebenezer Hill, Norwalk, Conn.

865,390. MEANS FOR UNLOADING AIR-COMPRESSORS. Ebenezer Hill, Norwalk, Conn.

865,424. AIR-COMPRESSOR. George C. McFarlane, Bay City, Mich. Filed March 28, 1906.

865,496. COMPRESSED-AIR MOTOR FOR AUTOMOBILE. Fred G. Herrington, Decatur, Ill.

865,615. AIR-BRAKE HOSE-COUPLING. Eugene W. Shaw, Weir, Kans.

865,622. NUT AND BOLT TURNING ATTACHMENT FOR PNEUMATIC HAMMERS. Charles Wilson, Chicago, Ill.

865,767. APPARATUS FOR SUPPLYING EXPLOSIVE-ENGINES WITH EXPLOSIVE MIXTURE. Charles G. Dean, Indianapolis, Ind.

865,941. PNEUMATIC TRACK-SANDER. Henry Rau, Jr., Baltimore, Md.

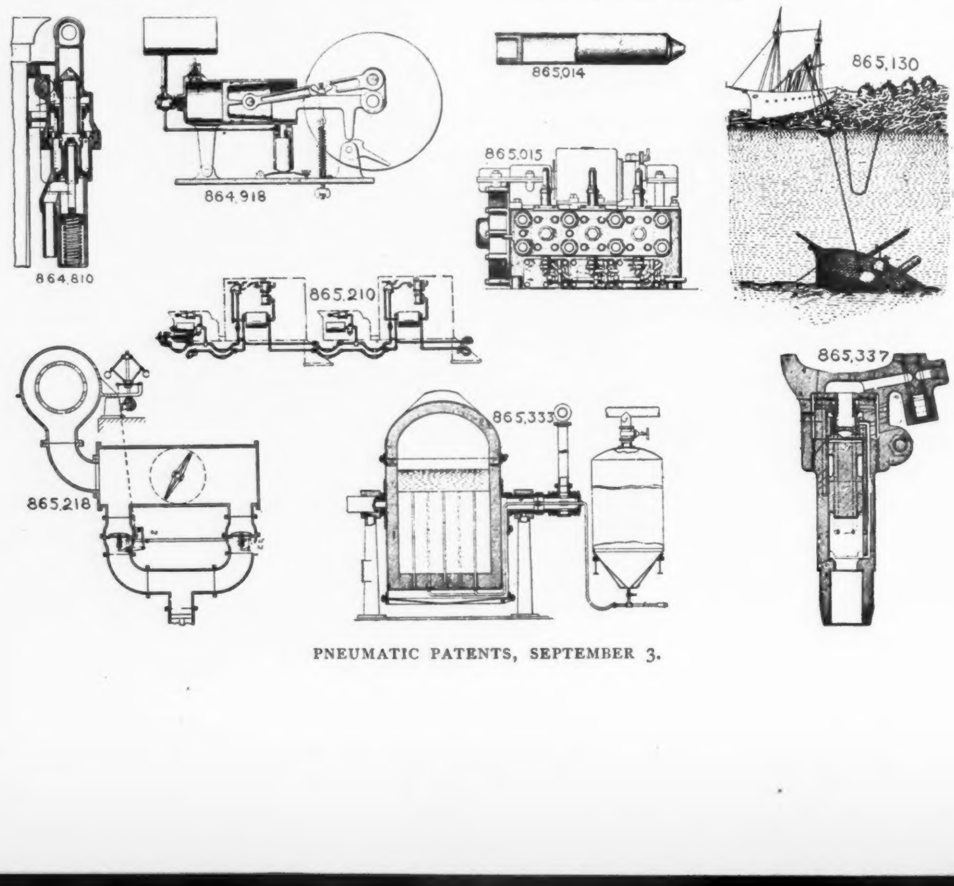
865,942. PNEUMATIC TRACK-SANDER. Henry Rau, Jr., Baltimore, Md.

865,949. VALVE FOR FLUID-PRESSURE ENGINES. William C. Schaff and Jacob A. E. Friederichs, San Bernardino, Cal.

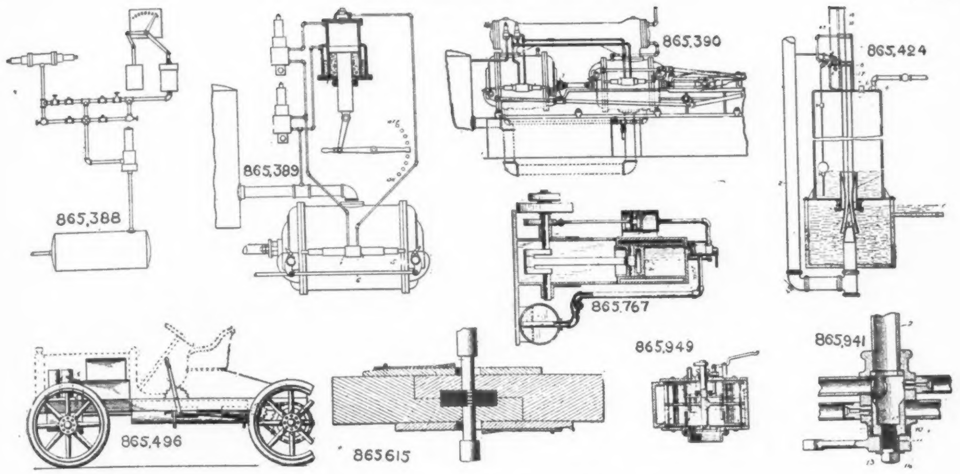
September 17.

866,041. DEVICE FOR SHARPENING ROCK-DRILLS. Elias Lewis, Denver, Colo.

866,171. ELASTIC-FLUID TURBINE. George Westinghouse, Pittsburg, Pa.



PNEUMATIC PATENTS, SEPTEMBER 3.



PNEUMATIC PATENTS, SEPTEMBER 10.

866,336. PNEUMATIC PIANO-PLAYER. Joseph Courville, Detroit, Mich.

866,348. MEANS FOR RAISING SUNKEN VESSELS. George Fearon and Christopher S. Fearon, Newcastle-upon-Tyne, England.

866,361. DRILL ATTACHMENT. Wilber R. Hitchcock, Cornwall, Ontario, Canada.

866,370. PNEUMATIC TOOL. Herman Leineweber, South Chicago, Ill.

866,415. PNEUMATIC SEPARATOR. Andrew M. Anderson and Cornelius Quesnell, Moscow, Idaho.

866,448. PRESSURE-GOVERNING DEVICE FOR PUMPS. Clyde C. Farmer, Chicago, Ill., and Walter V. Turner, Wilkinsburg, Pa.

866,457. COMPRESSED-AIR INSTALLATION. George J. Gibbs, Bamber Bridge, England.

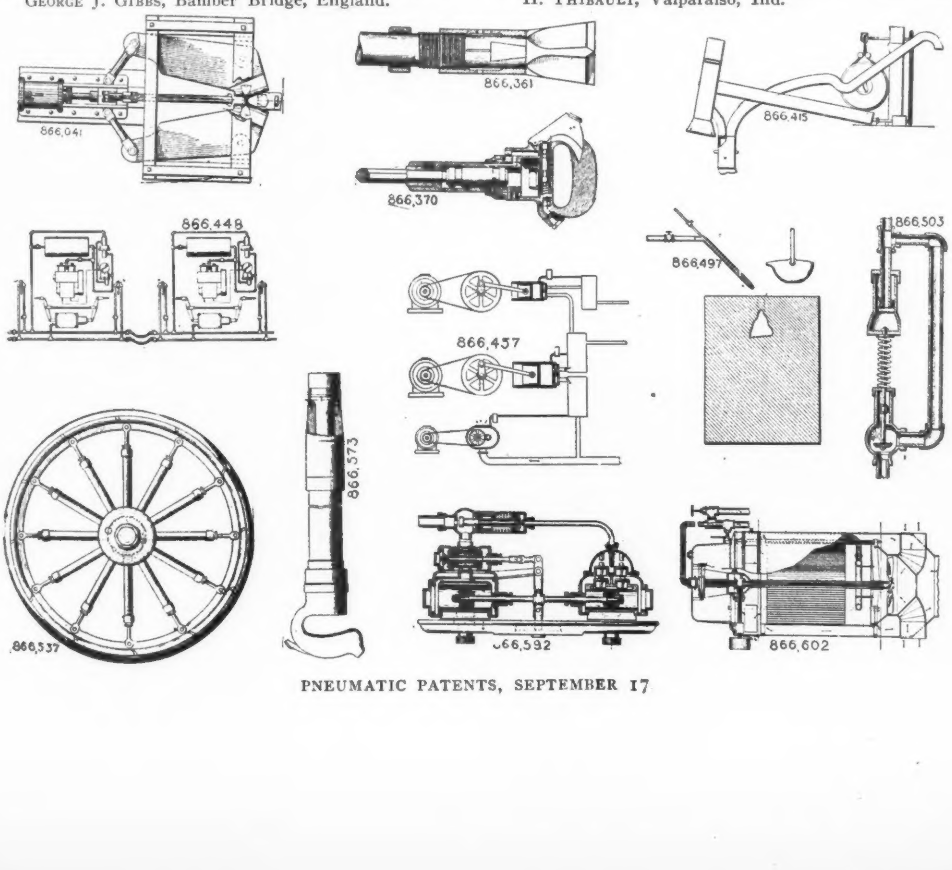
866,497. PROCESS FOR DOING AWAY WITH BLOW-HOLES AND LIKE FLAWS IN CASTINGS. Adolph E. Menne.

A process for doing away with hollows in castings, consisting in suitably placing the same, then applying an oxidizing gas under pressure to the top surface of the casting, then suitably starting the combustion of the gas and then partially igniting and melting the material of the casting and ejecting the material until the hollows are reached and then filling up said hollows with liquid metal, substantially as described.

866,503. FLUID-PRESSURE REGULATOR. Andrew J. Morehart, Fostoria, Ohio.

866,515. AUTOMATIC AIR-DAMPER. Arthur W. Puddington, Cleveland, Ohio.

866,537. PNEUMATIC-SPOKE WHEEL. Arthuer H. Thibault, Valparaiso, Ind.



PNEUMATIC PATENTS, SEPTEMBER 17

866,573. PNEUMATIC HAMMER. Joseph Boyer, Detroit, Mich.
866,591. FLUID-MOTOR. Hugh W. Kimes, Dayton, Ohio.
866,592. FLUID-MOTOR. Hugh W. Kimes, Dayton, Ohio.
866,602. AIR-TREATING MACHINE. Charles A. Rumble, Boston, Mass.

September 24.

866,623. VALVE-GEAR. William H. Collier, Jackson, Tenn.

In valve gear, the combination with a plurality of fluid-pressure-actuated valve-operating means, of a controlling valve for the same having ports adapted to register with ports of said valve-operating means, means for driving said controlling valve, and fluid-pressure means for shifting said valve in a direction other than that of its normal motion, said valve comprising means whereby when the valve is so moved in a direction other than that of its normal motion, the operation of said fluid-pressure-actuated valve-operating means is varied.

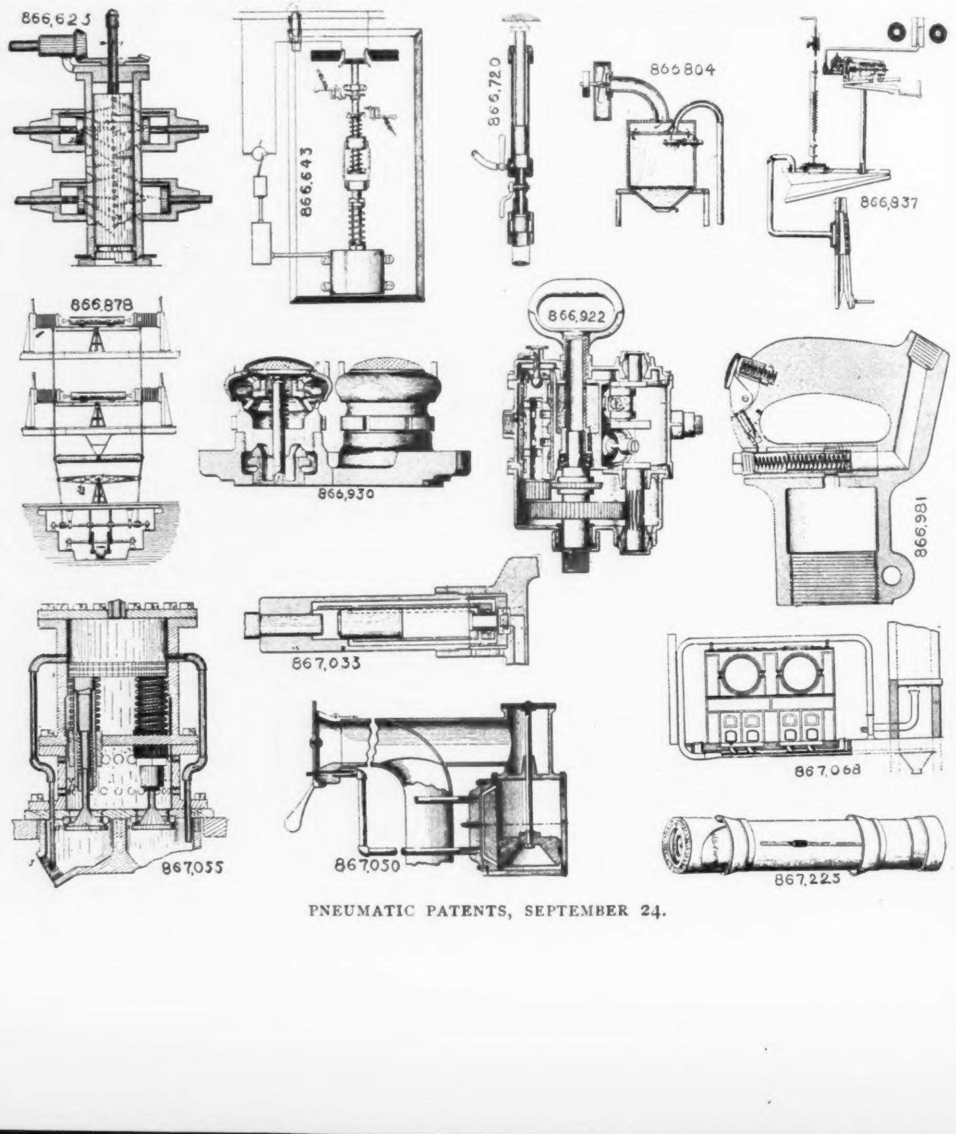
866,643. PRESSURE-CONTROLLER. James H. Glenn and Michael Reule, La Fayette, Ind.

The combination with the receiver of an electrically-driven compressor, a cylinder in communication with the receiver, a plunger working in the cylinder and spring-actuated to oppose the receiver pressure, and a plunger-stem; of a block carried by the plunger-stem and having an opening, a stem working in said opening and carrying circuit-closing means, a yielding connection between the plunger-stem and the circuit-closing stem at both ends of the aforesaid block, tensioned latches opposing the movement of the circuit-closing stem, the tension of said latches being greater than the yielding connection between the plunger-stem and the circuit-closing stem, and latch engaging means carried by the circuit-closing stem.

866,720. PNEUMATIC DRILL-FEED. George H. Gilman, Claremont, N. H.
866,804. PNEUMATIC CONVEYER. Samuel Olson, Chicago, Ill.
866,837. RELIEF-VALVE FOR TENSION-RESERVOIRS FOR PNEUMATIC APPARATUS. George P. Brand, New York, N. Y.
866,878. AIR-COMPRESSOR. Alexander McCarthy, New York, N. Y.

In an apparatus for the compression of air, the combination of an oscillating cylinder partially filled with fluid, means for oscillating said cylinder, a series of air compressing devices and said oscillating cylinder for the purpose specified.

866,922. ENGINE. William O. Duntley, Chicago, Ill.
866,930. AIR-STRAINER FOR SUCTION-VALVES. Maury W. Hibbard, Chicago, Ill.
866,981. PNEUMATIC TOOL. Joseph H. Templin, Philadelphia, Pa.
867,033. FLUID-PRESSURE POWER-HAMMER. Carl R. Green, Dayton, Ohio.
867,050. PNEUMATIC-DESPATCH-TUBE APPARATUS. Frank W. Knott, St. Louis, Mo.
867,055. AUTOMATIC AIR SANDING-MACHINE. Albert F. Kubicek, Chicago, Ill.
867,068. PNEUMATIC DELIVERY SYSTEM. William McClave, Scranton, Pa.
867,225. CARRIER FOR PNEUMATIC-TUBE APPARATUS. William A. Brown, Chicago, Ill.



PNEUMATIC PATENTS, SEPTEMBER 24.

Boxes, Kit and Tool.
Clark Co., W. J.
Brakes, Air.
Westinghouse Air Brake Co.
Castings, Steel.
Curtis & Co. Mfg. Co.
Cableways, Contractors'.
Lidgerwood Mfg. Co.
Channelers.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Charging Stations.
Porter Co., H. K.
Coal Cutters.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Coal Chutes, Steel.
Clark Co., W. J.
Coal and Ore Elevator Buckets.
Clark Co., W. J.
Cocks.
Powell Co., Wm.
Compressors, Air and Gas.
Blaisdell Machinery Co.
Bury Compressor Co.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
General Compressed Air and Vacuum Machinery Co.
Harris Air Pump Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Powell Co., Wm.
Rix Compressed Air and Drill Co.
Roteng Engineering Corporation.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.
Compressors, Gasolene Driven.
General Compressed Air and Vacuum Machinery Co.
Compressor Fittings, Air and Gas.
Powell Co., Wm.
Core Drills.
Harrison Supply Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Core Drills, Diamond.
Sullivan Machinery Co.
Core Drills, Diamondless.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Corliss Engines.
Cooper Co., C. & G.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Derricks.
Lidgerwood Mfg. Co.
Drilling Machines, Pneumatic.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Stearns-Roger Mfg. Co.
Electro-Pneumatic Machinery.
General Compressed Air and Vacuum Machinery Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.

(Continued on page 13.)

Engine Room Appliances.
Sargent Steam Meter Co.
Stearns-Roger Mfg. Co.
Fans, Ventilating.
Sprague Electric Co.
Sullivan Machinery Co.
Flue Rolling Machines.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
Foundry Appliances.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Goldschmidt Thermit Co.
Hanna Engineering Works.
Harrison Supply Co.
Ingersoll-Rand Co.
Foundry Facings.
Jos. Dixon Crucible Co.
Graphite Commutator Brushes.
Jos. Dixon Crucible Co.
Graphite Crucibles and Retorts.
Jos. Dixon Crucible Co.
Graphite Greases.
Jos. Dixon Crucible Co.
Graphite Paint.
Jos. Dixon Crucible Co.
Hammer Drills.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Hammers, Calking and Chipping.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Hammers, Riveting.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Ingersoll-Rand Co.
Stearns-Roger Mfg. Co.
Helmets, Sand Blast.
C. Druckleib.
Hoisting Machinery.
Lidgerwood Mfg. Co.
Sprague Electric Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Hoists, Air.
Blaisdell Machinery Co.
Chicago Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Rix Compressed Air and Drill Co.
Stearns-Roger Mfg. Co.
Hose Clamps.
Clark Co., W. J.
Ingersoll-Rand Co.
Hose Couplings.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Harrison Supply Co.
Ingersoll-Rand Co.
McKiernan Drill Co.
Revere Rubber Co.
Rix Compressed Air and Drill Co.

(Continued on page 14.)

Sprague Electric Co.
Stearns-Roger Mfg. Co.
Sullivan Machinery Co.
Westinghouse Air Brake Co.

Hose, Steam and Air.
Chicago Pneumatic Tool Co.
Cleveland Pneumatic Tool Co.
Curtis & Co. Mfg. Co.
Goodrich Co., The B. F.
Harrison Supply Co.
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(Continued on page 15.)

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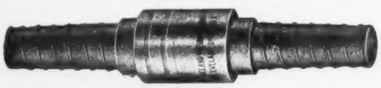

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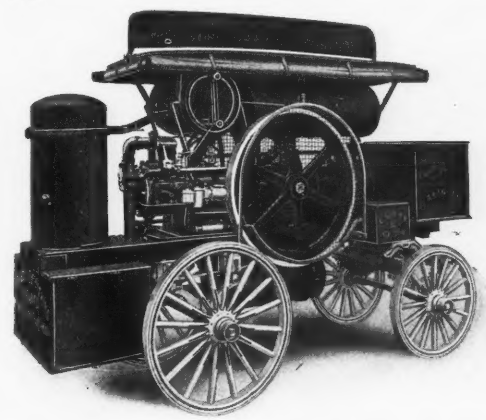

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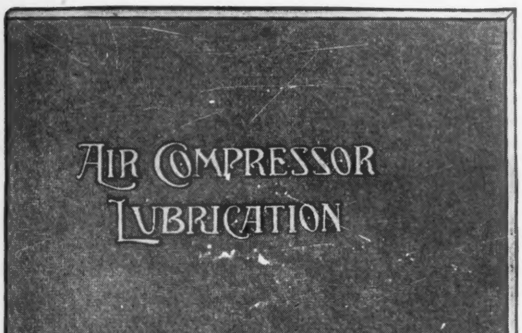

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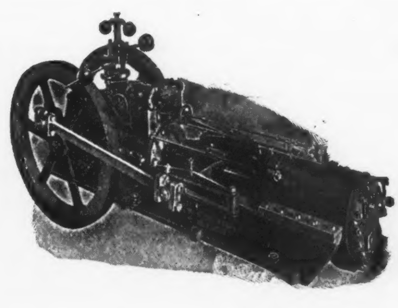

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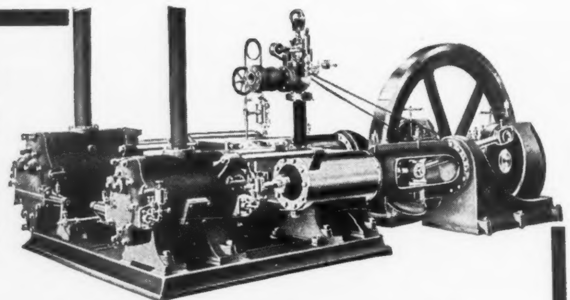

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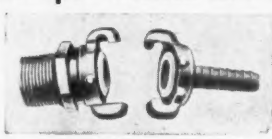

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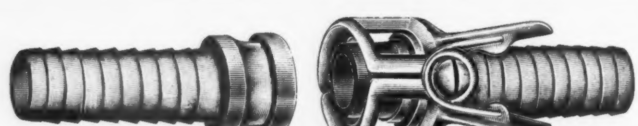

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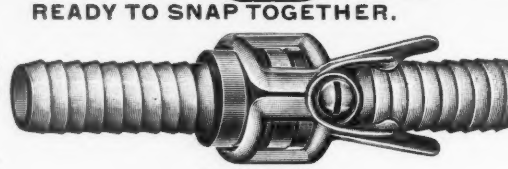

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